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Waste Minimization Opportunity Assessment
Scott Air Force Base

Science Applications International Corp., Cincinnati, OH

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WASTE MINIMIZATION OPPORTUNITY ASSESSMENT

SCOTT AIR FORCE BASE

by

Science Applications International Corporation
Cincinnati, Ohio 45203

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16. ABSTRACT

This report describes a waste minimization assessment of three operations at Scott AFB. Circuit board manufacturing, non-destructive wheel inspection, and paint stripping/painting/parts cleaning are the operations addressed in this assessment. The primary focus of the assessment was on the non-destructive wheel inspection and several options for reducing waste. This assessment was carried out under the WREAFS Program.

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air and water resources. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing and managing research, development and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs and regulations of the EPA with respect to drinking water, waste water, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

The Pollution Prevention Research Branch of the Risk Reduction Engineering Laboratory has instituted the Waste Reduction Evaluations at Federal Sites (WREAFS) Program to identify, evaluate and demonstrate waste minimization opportunities in industrial, military and other Federal facilities. EPA believes the WREAFS Program will show waste minimization to be a cost-effective tool in reducing the generation and disposal of hazardous and non-hazardous wastes. This report summarizes a waste minimization assessment of Scott Air Force Base, Illinois. Scott AFB is the headquarters for the 375 Aeromedical Airlift Wing of the Military Aircraft Command (MAC) and supports twelve C-9 aircraft.

E. Timothy Oppelt, Director
Risk Reduction Engineering Laboratory

ABSTRACT

This report summarizes work conducted at Scott Air Force Base (AFB) near Belleville, Illinois under the U.S. Environmental Protection Agency's (EPA) Waste Reduction Evaluations at Federal Sites (WREAFS) Program. This project was funded by EPA and conducted in cooperation with Air Force officials.

The purposes of the WREAFS Program are to identify new technologies and techniques for reducing wastes from industrial processes at federal sites, and to enhance the implementation of pollution prevention/waste minimization through technology transfer. New techniques and technologies for reducing waste generation are identified through waste minimization opportunity assessments and may be further evaluated through joint research, development, and demonstration projects.

A waste minimization opportunity assessment was performed during the fall-winter of 1990 which identified areas for waste reduction at Scott AFB. The study followed procedures in the EPA Waste Minimization Opportunity Assessment Manual. Although the base has made substantial progress to date, opportunities were identified for further action. This report identifies potential procedural initiatives as well as technology options to achieve further pollution prevention progress.

A number of waste generating processes were initially screened including: non-destructive inspection (NDI), painting/paint removal/parts cleaning and printed circuit board manufacturer. Detailed technical evaluations were performed on non-destructive inspection options. No detailed analysis were performed for other processes because the Air Force was either past or near the implementation phase. Options identified for non-destructive inspection were as follows:

- Option 1 - Modify Eddy Current Equipment
- Option 2 - Modify standing operation procedures (SOP) for Change-out of Emulsifier and Developer
- Option 3 - Switch to Silica-based Dry Developer.

Research needs were identified for all processes initially screened.

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This report was prepared for EPA's Pollution Prevention Research Branch by Gary Baker, George Wahl, and William McNeil of Science Applications International Corporation for the U.S. Environmental Protection agency under Contract No. 68-C8-0061.

SECTION 1

INTRODUCTION

PURPOSE

The purpose of this project was to conduct a Waste Minimization Opportunity Assessment (WMOA) for selected processes at Scott Air Force Base (AFB). The assessment was conducted for the EPA's Risk Reduction Engineering Laboratory under the purview of the Waste Reduction Evaluations at Federal Sites (WREAFS) Program of the Pollution Prevention Research Branch. A procedure described in the EPA Waste Minimization Opportunity Assessment Manual (EPA/625/7-88/003) was used to conduct the study. The manual provides detailed worksheets and a process/option evaluation method for use in industrial settings.

A WMOA consists of four systematic steps: Planning and Organization, Assessment, Feasibility Analysis, and Implementation. Figure 1 presents the WMOA process. Of the 19 worksheets in the WMOA manual, selected sheets were completed for the processes and waste minimization options considered. The detailed worksheets used are presented in Appendix A. The implementation of the recommended options presented in this report is at the discretion of the host facility.

APPROACH

Scott AFB is located near Belleville, Illinois. About 3,000 civilians and 5,000 military personnel either work or live there. The base is part of the Military Airlift Command (MAC), and operates and maintains a fleet of C-9 medical aircraft. Twelve C-9s are outfitted, flown and maintained in a ready condition by base staff.

After preliminary discussions between EPA and MAC, the WMOA team was organized and assembled at Scott AFB. The overall organization of the EPA project team and the participants from Scott are shown in the worksheets in Appendix A.

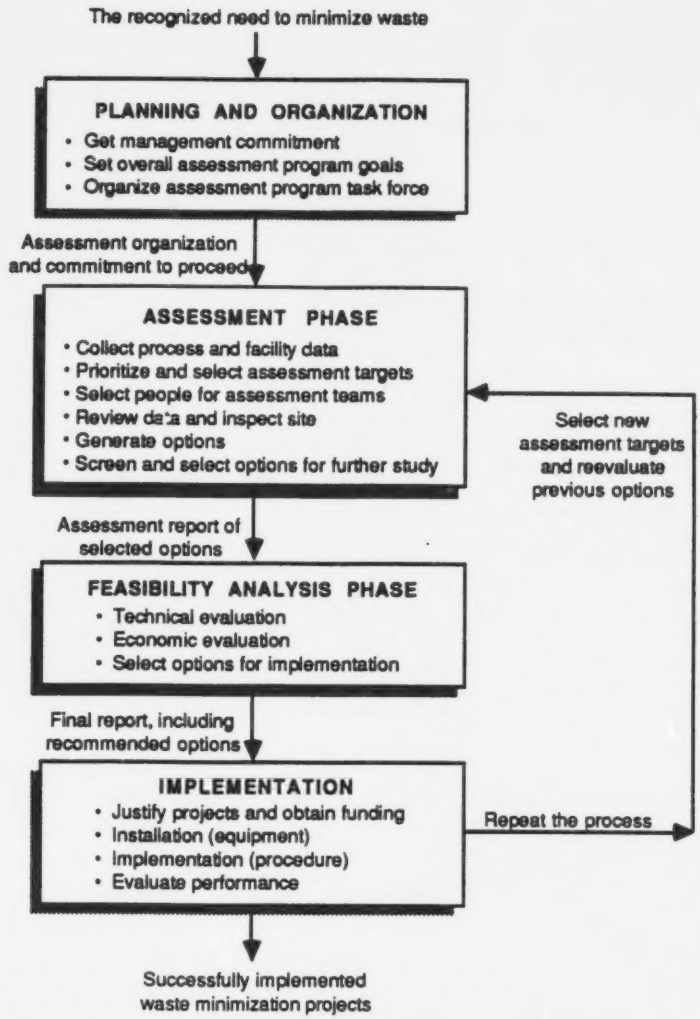

The recognized need to minimize waste
PLANNING AND ORGANIZATION
• Get management commitment
• Set overall assessment program goals
• Organize assessment program task force
Assessment organization and commitment to proceed
ASSESSMENT PHASE
• Collect process and facility data
• Prioritize and select assessment targets
• Select people for assessment teams
• Review data and inspect site
• Generate options
• Screen and select options for further study
Select new assessment targets and reevaluate previous options
Assessment report of selected options
FEASIBILITY ANALYSIS PHASE
• Technical evaluation
• Economic evaluation
• Select options for implementation
Final report, including recommended options
IMPLEMENTATION
• Justify projects and obtain funding
• Installation (equipment)
• Implementation (procedure)
• Evaluate performance
Repeat the process
Successfully implemented waste minimization projects

Figure 1. The Waste Minimization Opportunity Assessment Process

SECTION 2

PROCESS REVIEW

Scott AFB personnel perform numerous industrial process operations that generate hazardous waste. Base environmental staff have prepared a Hazardous Waste Management Plan, dated August 1990, that identifies the waste streams on base. Wastes range from infectious waste from the medical unit to various solvents used in printing, painting, depainting, and vehicle maintenance. The list of waste streams is presented in Appendix B.

Discussions with base environmental staff and EPA resulted in a focus on three areas of investigation:

- non-destructive inspection (NDI) of C-9 wheel hubs,
- painting/paint removal/parts cleaning, and
- printed circuit board manufacture.

Tours of each of these three areas were conducted, and relevant data were gathered. Subsequent to the process inspection, worksheets were provided to Scott AFB environmental personnel for completion. These inputs, plus calls to the various points of contact on base for follow-up data and options reviews with equipment and chemical vendors, form the basis for this report.

The following sections describe each of the three selected processes, the wastes generated and the current status of base actions to reduce the initial volume and/or toxicity of wastes generated.

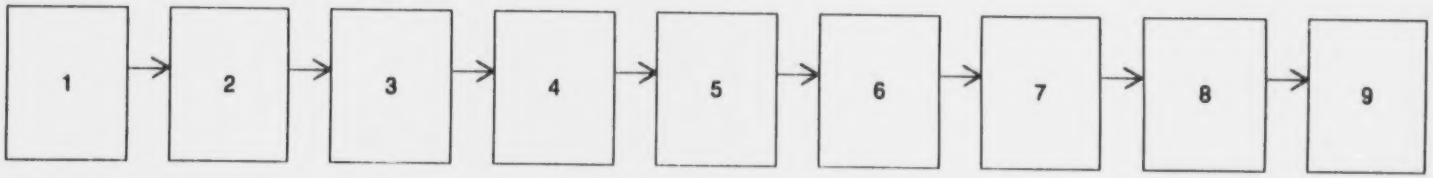
NON-DESTRUCTIVE INSPECTION (NDI)

As part of the preventative maintenance practices on the C-9s, landing wheels are inspected for signs of fatigue such as cracks or other discontinuities that penetrate to the surface. Two test methods are used at Scott AFB to inspect wheels. An eddy current method is used to inspect the bead seat area, and a liquid penetrant inspection method is used to check all other areas. The eddy current method places an electric current in proximity to a conductive test specimen (such as the aluminum wheel) and measures impedance changes due to discontinuities. Eddy current, unlike liquid penetrant inspection, does not result in the generation of waste.

A process flow diagram of the liquid penetrant process at Scott AFB is presented in Figure 2. Aluminum wheel halves are immersed long enough for the penetrant to permeate into any discontinuities that are accessible from the surface. After the specified soak time, the parts are placed over a drip station that returns surface runoff back to the penetrant tank. The part is then rinsed with water, then re-immersed in an emulsion solution for a specified time, removed and rinsed again to remove penetrant from the surface of the parts. Next, the parts are soaked in a developer which deposits a thin layer of solid material on the surface of the part. Parts are placed above the developer where surface runoff is returned to the developer tank. The parts are placed in a dryer at a specified temperature and time. After drying, parts are inspected under ultraviolet (UV) light. Cracks are indicated by fluorescent lines or spots. Parts can then be rejected or repaired as warranted. To date, only three failures have been detected from wheel inspections in approximately 20 years (approximately 1000 wheel inspections). The process is, however, a mandatory part of routine aircraft maintenance prescribed by FAA and military specifications.

The three primary wastes generated by the NDI process are the penetrant, emulsifier and developer. The penetrant tank is emptied and refilled to prevent contaminants from impacting sensitivity. If foreign material fills the voids left by surface discontinuities, this would prevent the penetrant from establishing itself in critical areas. The need for change-out is determined by periodically comparing two test specimens with known flaws. One is dipped in the current batch of penetrant solution while the other is dipped in an unused portion. If a noticeable visual difference in intensity of the failure occurs, the penetrant batch is changed-out. Each batch is approximately 100 gal. Discarded penetrant is transferred to 55-gal drums, which are picked up by a waste handler and incinerated in a cement kiln. The Defense Reutilization and Marketing Office (DRMO) currently classifies the penetrant waste as a D001 (flammable) waste; however, the flash point is above the 140°F criteria established for D001 waste. Batch life ranges from 2 to 4 years and is dependent on the age of the wheels (older wheels require more frequent inspection than newer wheels and therefore contaminate the batch sooner).

A small amount of penetrant is lost to the sewage treatment plant during the rinse operation when wheels are rinsed prior to being dipped in the emulsifier. The Air Force is considering an oil-water separator to recover the penetrant from this stream.



9 Stations to Penetrant Line

1) Penetrant tank (110 gallons)
2) Drip station
3) Rinse station
4) Emulsion tank (110 gallons)
5) Rinse station
6) Developer tank (110 gallons)
7) Drip station
8) Parts dryer
9) Inspection booth

Note: The penetrant line is setup on the back wall of the NDI shop.

Figure 2. Process Flow Diagram of Non-Destructive Inspection Using Dye Penetrant at Scott Air Force Base

The emulsifier batch eventually becomes contaminated with penetrant solution due to incomplete rinsing. The batch is changed-out about every six months (based on a standard operating procedure) and sent to the sewage treatment plant through a floor drain. The batch sizes are approximately 100 gal each. Although the waste is not hazardous, the manufacturer recommends disposing of the waste by incineration. A small amount of emulsifier is discarded to the sewage treatment plant with the post-emulsifier rinse water.

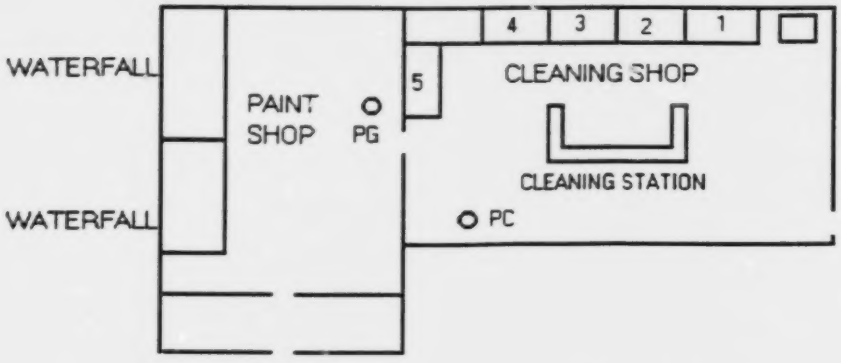
Developer batches become contaminated primarily with penetrant. Batches of approximately 100 gal are changed out on about the same frequency as the emulsifier batches. Like the emulsifier, the developer is currently sent to the sewage treatment plant through a floor drain. Unlike the emulsifier though, the waste is hazardous according to the developer manufacturer. Due to the levels of sodium chromate present, the batches meet the criteria for a D007 waste and should not be directed to the sanitary system.

PAINTING/PAINT REMOVAL/PARTS CLEANING

The paint shop maintains all aerospace ground equipment (AGE) for Scott AFB. Paint booths are normally used during one 8-hour shift per day, but can be operated around-the-clock during peak times. Approximately 24 one-gal kits of polyurethane paint are used per year. About 90% of the paint used at the paint shop is polyurethane and the remainder is various lacquers and varnishes.

Parts to be painted are dry-sanded or dipped into a bath containing a multi-layer stripping solvent. This solvent is used until contaminated with paint sludge; it is then drummed and hauled away as a hazardous waste. About 50 to 75 gal of waste stripper are hauled away by a waste handler every three months. The waste is classified as a F002 waste and its disposal cost is about $6.00 per gal. This process is to be replaced by a plastic media blasting (PMB) method. The PMB equipment is located onsite and lacks only some minor fittings before it can be operated.

Parts requiring a clean, grease-free surface for subsequent processing such as inspection or repainting are brought into the Cleaning Shop (see Figure 3). Excess grease is wiped off and the parts are immersed in a bath of Safety Kleen 105 degreaser for at least 45 min. The part is then removed and manually scrubbed with a scrub brush. Any remaining solvent is rinsed off at a cleaning station. The Base contracts with Safety Kleen, Inc. to remove the contaminated solvent and replace it with fresh solvent. Safety Kleen Inc. then recycles the solvent and distributes it back to its customers. The consumption of solvent is approximately 213 gal every 6 weeks. The solvent is primarily mineral spirits and is classified as a D001 waste because of its 105°F flash point temperature. Before switching to Safety Kleen 105, the cleaning shop used PD-680 for degreasing. PD-680 contains petroleum distillates and is considered hazardous.



1 - Stripper (110 gal.)
2 - Water/barrel of alodine
3 - Empty
4 - Empty/barrel of acid
5 - Safety Kleen Solvent (220 gal.)
PC - Safety Kleen Parts Cleaner (5 gal.)
PG - Safety Kleen Paint Gun Cleaner (5 gal.)

Figure 3. Diagram of the Parts Cleaning Process at Scott Air Force Base

Parts such as aluminum alloy landing wheels are next dipped into a weak acid solution to remove oxidized metal from the surface in a process referred to as pickling. Since the metal now has a bare surface, the wheel is dipped into a solution containing a corrosion inhibitor. The acid solution used for pickling and the solution of corrosion inhibitor do not result in the generation of waste because they are both continually replenished as needed.

Polyurethane finish is applied to parts in spray paint booths similar to the one shown in Figure 4. A Devilbiss 502 paint gun with suction feed is used to transfer paint to parts. Paint guns are typically operated at 45-55 psi. A down-draft water curtain removes overspray solids from the booth's ventilation exhaust. In order to prevent nozzle clogging, paint guns are cleaned out with a paint thinner on a routine basis. The wastes generated by this process are overspray solids, booth compound, booth waste water, waste paint and thinner, and volatile organic compounds (VOCs).

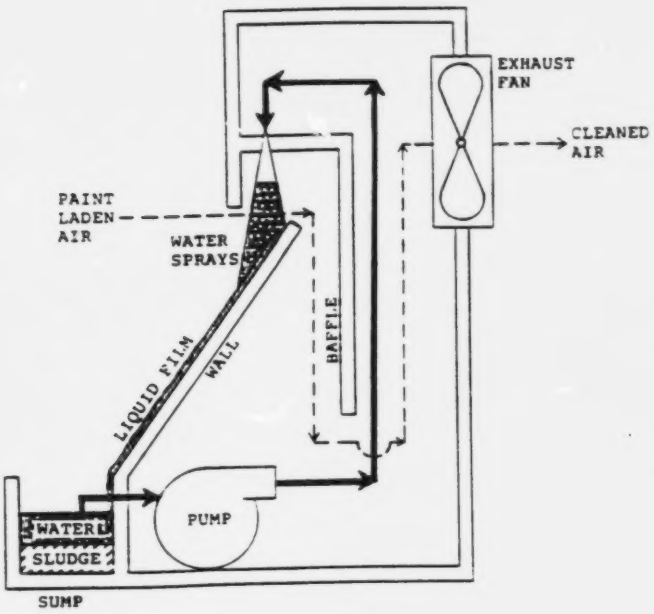


Figure 4. Diagram of the Painting Process at Scott Air Force Base

The current paint guns used in the Paint Shop typically transfer 50% of the paint to the target (when used properly). The overspray contains solids which become entrained in the waterfall curtain. These solids accumulate as either floating scum or sludge. About 220 gal of sludge and scum are placed in 55-gal drums and hauled away each year. Booths are periodically coated with a protective film called booth compound to prevent adhesion to the metal walls. This material eventually peels from the booth surfaces or is manually peeled as it deteriorates. A new coating is then applied and the old compound discarded with drummed sludge. The booth water is drained to the sewage treatment plant bi-monthly in order to remove the sludge. No water treatment chemicals are added to the booth water.

Paint thinner is used to clean paint gun nozzles to prevent clogging. The mixed thinner and paint along with unused paint, are placed in 30-gal drums for disposal by Safety Kleen Inc. every 8 weeks. About 900 gal of this waste are generated annually.

VOCs are released during atomization of the paint by the spray guns. The water curtain does not control the emissions of these VOCs to the atmosphere since they are not soluble in water. The amount of VOCs generated depend on the amount of paint used and the amount of volatiles in the paints used. No estimate of the amount of VOCs emitted was made by Scott AFB personnel.

PRINTED CIRCUIT BOARD MANUFACTURE

Scott AFB maintains a laboratory-scale circuit board production capability located in Building 3190. The operation produces a small quantity of circuit boards which are needed as replacement parts or special designs for electronic instrumentation. Large quantity orders for circuit boards are not handled by the facility.

Circuit boards are manufactured using a proprietary process, the Kepro Plate-Thru System which is marketed by Kepro Circuit Systems Company of Fenton, Missouri. Electroless copper plating, electrolytic copper plating and tin-lead plating are used to form electrical circuits on fiberglass circuit boards. Metal is either deposited on or removed from the fiberglass surface forming the circuit pattern. The areas affected by these steps are controlled by use of laminated films of "photoresist". This is a photosensitive material which becomes resistant to specific chemical solvents when exposed to ultraviolet (UV) light. The process, illustrated in general in Figure 5 and in more detail in Appendix C, is complex and uses a number of chemicals.

Two-sided copper-clad circuit boards are pre-drilled to form holes in which copper is deposited to connect circuit elements on opposite sides of the board. The boards are then cleaned in several steps using PTH, a proprietary alkaline cleaner; acidic ammonium persulfate; and dilute sulfuric acid. They are then immersed in dilute hydrochloric acid followed by immersion in an activating solution of ACT-1G, which contains tin-palladium.

After the activation step, the circuit boards are rinsed and then immersed in an accelerator solution to enhance the electroless copper deposition. A two-step rinsing process is used at this point.

The electroless copper plating solution is proprietary; its composition was not given. However, solutions of this type typically contain a copper salt such as copper sulfate; a reducing agent such as formaldehyde, hydrazide, or sodium hypophosphite; a complexing agent such as sodium or potassium tartrate or EDTA; a stabilizer such as thiourea, thiodiglycol, or vanadium oxide; and acid or base for pH adjustment. The solution in use at Scott AFB has a pungent aldehyde odor and probably contains

formaldehyde as the reducing agent. The electroless copper plates out on all surfaces that have been activated with palladium, thus provides a continuous layer of copper through the holes in the circuit board, connecting the two copper layers.

After the electroless copper deposition step, the boards are rinsed, immersed in dilute sulfuric acid, and electroplated with copper to build up the metal thickness. The electroplating solution is also a proprietary material.

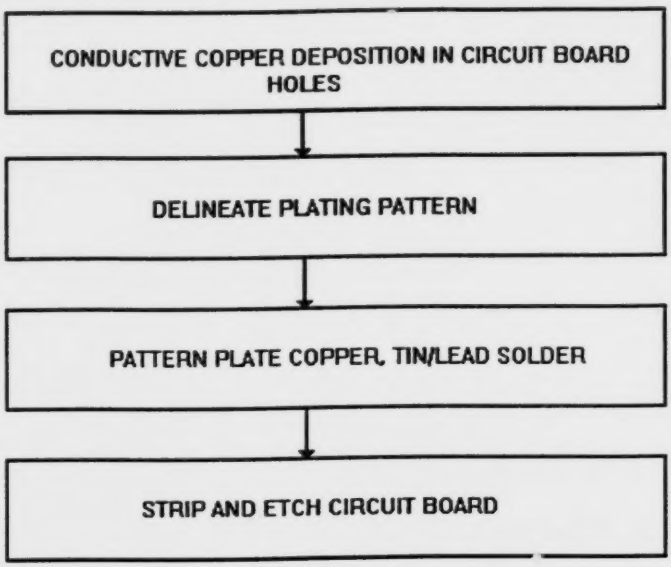

CONDUCTIVE COPPER DEPOSITION IN CIRCUIT BOARD HOLES
DELINEATE PLATING PATTERN
PATTERN PLATE COPPER, TIN/LEAD SOLDER
STRIP AND ETCH CIRCUIT BOARD

Figure 5. Simplified Diagram of the Circuit Board Manufacturing Process at Scott Air Force Base

The photoresist process is used to define the areas of the circuit board where metal will be removed or retained to form circuit elements. The photoresist material is applied to the board with a laminating machine which applies a 0.0015 in thick coating to both sides. After curing, the polyester cover sheet is removed from the photoresist coating and placed face-down on a photographic film positive of the circuit over a UV light source. The circuit element pattern is opaque and the background areas, where metal will

be removed from the circuit board, are transparent. The board with the film positive mask is illuminated for 3.5 min with UV light causing the photoresist material to become resistant to attack by developer (a sodium carbonate solution). The photoresist material in the areas masked by the opaque circuit pattern are not exposed to the UV light and remain soluble in the developer solution. The circuit board is sprayed with developer solution and rinsed to remove the photoresist material from the areas which will become circuit elements.

The exposed copper surfaces are then cleaned in acidic ammonium persulfate solution, rinsed, acid treated, and electroplated with copper for 36 min to build up metal thickness. A tin-lead solder layer is electroplated over the copper which completes the formation of the metallic circuit elements. The tin-lead solder layer protects the underlying copper in the final steps of the process where copper metal is removed from the areas that are not part of the metallic circuit pattern.

The photoresist material that had been "hardened" by exposure to UV light remains on the circuit board when it is sprayed with sodium carbonate developer solution, and these are were not plated with copper or tin-lead solder. In order to remove metal from these surfaces, the photoresist material is stripped in stripper solution (an aqueous solution of potassium hydroxide). After rinsing, the underlying copper is removed by etching. This removes all the excess copper between the circuit elements which are protected by the tin-lead solder layer and not affected by the etchant. After a final rinse and drying, the circuit board is complete.

The three principal wastes are:

- Electroless Copper Solution, ECU-10G, approximately 45 gal/yr
- Sodium Persulfate Solution, SP-20, approximately 60 gal/yr
- Ammonium Persulfate Solution, AP-20G, approximately 45 gal/yr

These are collected in 15-gal containers, labelled, and transferred to the DRMO for disposal. Other process wastes (including numerous water rinses) are discharged to the waste sewer line.

If the sodium persulfate and ammonium persulfate solutions are hazardous wastes, it would be on the basis of exhibiting the characteristic of corrosivity (D002). The electroless copper solution probably contains formaldehyde, a listed non-acute hazardous waste (U122).

SECTION 3

WMOA ASSESSMENT/FEASIBILITY

The assessment team visited three areas at Scott AFB; NDI, painting/paint removal/parts cleaning and printed circuit board manufacture. NDI was of special interest to the EPA because of its widespread use in the military and commercial airlines. The WM options identified during the detailed analysis of the NDI process are discussed in this section and summarized in Table 1. No detailed analyses were performed for the other processes because the Air Force was either past or near the implementation phase for several options. A brief discussion of painting/paint removal/parts cleaning and printed circuit board manufacture is included in this section to highlight the current status of the Air Force's effort and to suggest further enhancements. Since the exact composition of solutions used for printed circuit board manufacture were proprietary, many uncertainties remain regarding the circuit board operation.

NON-DESTRUCTIVE INSPECTION (NDI)

Option One- Modify Eddy Current Equipment

The Air Force has tried to address the waste generated by NDI inspection in the past. A feasibility study was conducted to determine if the eddy current equipment could be modified to handle the complete inspection including areas other than the bead seat area. The Air Force determined that modifying the equipment was cost prohibitive.

Option Two- Modify SOP for Change-out of Emulsifier and Developer

The current operating procedure requires that the emulsifier and developer tanks be completely emptied and cleaned about every 6 months to remove contaminants and adjust the fluid characteristics to original specifications. The primary contaminant (the penetrant) floats on or near the surface because of its low density. This option involves an inexpensive method of periodically skimming the top layer of fluid. By skimming off the top layer and adding fresh makeup of emulsifier or developer, respectively, contaminants floating at or near the surface can be removed, and suspended contaminants can be diluted.

Based on telephone conversations with the emulsifier and developer supplier (Magnaflux), extending bath life is an accepted and proven method of waste reduction. The supplier provided information on a testing program they provide to customers to certify batch quality and optimize operation of NDI equipment. Some customers are able to extend emulsifier and/or developer batch life significantly by skimming penetrant off the top and monitoring the effectiveness of contaminant removal with this testing program. The Air Force could conduct the testing onsite, but should still consult the supplier to determine if the current QA/QC program is adequate. The frequency of testing and number of test methods used may need to be increased.

Removing floating penetrant could be accomplished by simply installing a drain valve on the side of the tank. In order to assure adequate contaminant removal, the assessment was based on draining off 25 gal or 25% from each tank every six months and complete draining and cleaning out every two years. With this amount of makeup, contaminant build up should be controlled. This method has minimal capital cost, little or no impact on operation of NDI equipment, and no additional O&M costs. The option represents a payback period of about 3 months. The option is also flexible in that the makeup and clean out schedule suggested in this report can be easily modified. The suggested schedule assumes removal of 8 in of fluid to eliminate the contaminants at the surface. Selecting 25-gal increments simplifies refilling the developer tank (after refilling to the 100-gal level, one full bag of developer mix is required).

Option Three-Switch to Silica-Based Dry Developer

Magnaflux reports that they rarely specify wet developer baths with new dye penetrant inspection systems. To eliminate the need for the wet chromate solution, new systems use a dry, non-hazardous, (silica-based) developer. These dry systems apply developer to the parts in one of two methods. The first, called a swirl cloud, involves placing the part in a shallow tank above a bed of dry developer and expanding the bed of developer with air. The other method, called a dynamic cloud, subjects the part to a fine spray of dry developer similar to a painting-type process. The dynamic cloud is generally preferred because it delivers a more uniform coating on the part and minimizes the amount of developer used. Dry developer application for either method is carried out in an enclosed booth and excess dust is collected by a filter system.

Changing to the silica-based developer would be technically feasible. The same equipment and materials used for penetrant and emulsifier application could be used. The current process line would have to be modified so that the dryer preceded the developer station. Some additional space, roughly twice the height of the current developer station, would be required to accommodate the dry developer booth.

TABLE 1. SUMMARY OF WASTE MINIMIZATION FEASIBILITY ANALYSIS PHASE

Waste Minimization Options	Waste Streams Affected	Nature of WM Option	Capital Investment $	Net Operating Cost Savings * $/yr	Payback Period (yr)	Rank Low to High (1-7)
Modify Eddy Current Equipment	Penetrant Emulsifier Developer	Equipment	70,000	4,440	15.8	2
Modify SOP for Change-out of Emulsifier and Developer	Emulsifier Developer	Personnel/ Procedure, Equipment	330	1,390	0.24	6
Switch to Silica-Based Dry Developer	Developer	Materials, Equipment	11,000	400	27.5	1

* Disposal costs associated with wet developer were neglected due to uncertainty about how it will ultimately be handled.

Switching to the dry developer would not adversely affect the sensitivity of the inspection. Magnaflux states that the dynamic cloud yields better sensitivity because a thinner and more uniform coatingcan be achieved. The dry developer is technically equivalent and meets the same specifications as the current wet developer (including MIL-I-25135 REV.E).

PAINTING/PAINT REMOVAL/PARTS CLEANING

The plastic media blasting equipment should be used to eliminate the use of organic solvents in paint stripping. The equipment is onsite and only lacks a few miscellaneous parts before operation can begin.

A comprehensive water treatment program for the wet spray booths should be initiated. The percent solids in the sludge could be increased through addition of a coagulant, reducing disposal costs and the frequency of removal. A number of water treatment companies provide products to optimize wet booth performance.

Conversion from wet operation to dry booth operation would result in volume reduction of wastes associated with painting. Filters would be used to collect overspray solids instead of a water curtain. Dry paint booths do not generate any sludge or waste water but require the disposal of filters.

The Air Force is implementing the use of high volume, low pressure (HVLP) paint guns. Two such guns (which cost approximately $1,200 each) are on order. The amount of overspray solids and VOCs generated can be substantially reduced. HVLP paint guns can reduce overspray from over 50% to about 10 to 20%. Since the painting is more efficient less paint is required, less VOCs are emitted, and less solids are collected by the water curtains. Other methods of controlling VOCs include the use of powdered coating and/or the use of electrostatic spraying systems.

PRINTED CIRCUIT BOARD MANUFACTURE

Scott AFB personnel have worked diligently to ensure the circuit board operation is following the standard operating procedures developed by the supplier. The current process is very complex with many steps in which solution compositions, treatment times, and temperatures are closely regulated; it may be difficult to modify the process and attain required product quality. One approach to waste minimization that might be considered, however, would be to change the electroless copper plating solution to eliminate materials such as formaldehyde. Other reducing agents such as sodium hypophosphite would be preferred and produce good quality electroless copper deposits.

It is difficult to speculate on options for further changes to the process due to the uncertainty of the actual composition of the proprietary solutions used. Also, the small scale of the process may not justify the cost of possible options.

RECOMMENDATIONS

The results of the study indicate that the fastest payback (0.24 year) would be from Option 2. Option 2 involves modifying the standard operating procedure for changeout of the emulsifier and developer. Under this option, the bath life of developer and emulsifier was extended by skimming off floating contaminants. The capital outlay needed for this option is estimated to be only $330.

Options 1 and 3 had payback periods of 15.8 and 27.5 years, respectively. Option 1 involved modifying the eddy current equipment so that it could replace the dye penetrant method for inspection of the wheel's bead seat area. This method had the highest cost savings, but with a capital cost of $70,000 (reported by Orville Robison) it is not economically feasible. Option 3, switch to silica-based dry developer, has moderate capital investment but low cost savings. If Scott AFB later determines that the wet developer should be treated as a D007 waste, the disposal costs for wet developer will increase and Option 3 will have a higher cost savings.

SECTION 4

IDENTIFICATION OF RESEARCH NEEDS

Two of the three process areas at Scott AFB have been thoroughly studied at other industrial and Federal facilities. Numerous pollution prevention options have been identified for painting/paint removal/parts cleaning and for printed circuit board manufacture. The Air Force is implementing plastic media blasting for paint removal and the use of high volume, low pressure paint guns. Degreasing operations could be conducted with alkaline cleaners instead of Safety Kleen 105, so that the generation of the waste could be significantly reduced. Printed circuit board waste generation is being minimized; the suggested options of copper recovery and elimination of the formaldehyde waste should be actively pursued with the vendor of the proprietary system. The following list of EPA publications should be reviewed for other pollution prevention options for these two process areas:

- EPA/625/7-90/007, June 1990. Guides to Pollution Prevention: The Printed Circuit Board Manufacturing Industry.
- EPA/625/4-89/021, September, 1989. Seminar Publication: Solvent Waste Reduction Alternatives.

In addition, other sources of information include the WMOA report publications (Appendix D) and the EPA's Pollution Prevention Information Clearinghouse database.

Non-destructive inspection processes have not been previously evaluated. Dye penetrant inspection methods were therefore of particular interest to EPA. Research into the specific requirement for the penetrant method of NDI must be thoroughly conducted so that dry, electromagnetic or ultrasonic methods are not obviated for this particular application. FAA regulations and wheel hub manufacturer recommendations must be reviewed.

The current system vendor must be contacted for relevant performance data for the dry developer booth. Based on the extremely low frequency of use of the NDI System, an external contractor to perform the service (with appropriate record keeping and documentation) should be considered. A local contractor is preferable to minimize hub damage during the transport.

At the time of the WMOA survey, the NDI System was to be relocated. This action should be coordinated with the potential for using the dry developer, modification of the NDI process line and implementation of the vendor's sampling/testing program.

Research at the on-site, industrial engineering level is all that should be required if Options 2 and 3 for NDI are implemented.

APPENDIX A

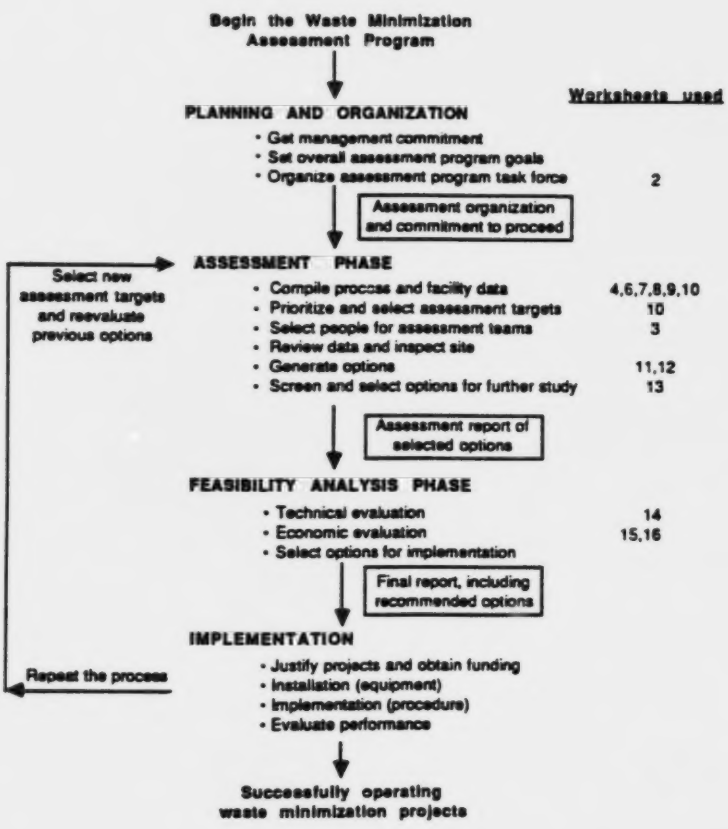
Assessment/Feasibility Phase Worksheets

Firm USAF	Waste Minimization Assessment Worksheets	Prepared By G. C. Wahl
Site Scott AFB, IL		Checked By G. E. Baker
Date 12/17/90	Proj. No. 1-832-03-200-30	Sheet 1 of 1 Page ___ of ___

WORKSHEET 1

ASSESSMENT OVERVIEW

EPA



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WORKSHEET 2

PROGRAM ORGANIZATION

EPA

FUNCTION	NAME	LOCATION	TELEPHONE #
Program Manager	G. Baker, SAIC	Cincinnati, OH	(513) 723-2600
Site Coordinator	M. Lanctot, USAF	Scott AFB, IL	(618) 256-2092
Assessment Team Leader			

Organization Chart

(sketch)

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WORKSHEET 3

ASSESSMENT TEAM MAKE-UP

EPA

Function/Department	Name	Location/ Telephone #	Manhours Required	Duties		
				Lead	Support	Review
Assessment Team						
Leader	Baker, SAIC	(513) 723-2600				
Site Coordinator	Lanctot, USAF - DEEV	(618) 256-2092				
Operations						
Engineering						
Maintenance	Robison/Reinard	(618) 256-3047/3756				
Scheduling						
Materials Control						
Procurement						
Shipping/Receiving						
Facilities						
Quality Control						
Environmental						
Accounting						
Personnel						
R & D						
Legal						
Management						
Contractor/Consultant						
Safety						
	McNeil, SAIC	(303) 278-8480				
	Wahl, SAIC	(513) 723-2607				

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WORKSHEET 4

SITE DESCRIPTION

EPA

Firm:	United States Air Force
Plant:	Scott Air Force Base
Department:	
Area:	
Street Address:	
City:	
State/ZIP Code:	
Telephone: ( )	
Major Products:	
SIC Codes:	
EPA Generator Number :	
Major Unit or:	
Product or:	
Operations:	Non-destructive inspection
	Circuit board production
	Paint stripping/Painting/Parts cleaning
Facilities/Equipment Age:	

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WORKSHEET 5

PERSONNEL

EPA

Attribute	Overall	Department/Area			
Total Staff	8,000	N/A	N/A	N/A	N/A
Direct Supv. Staff		N/A	N/A	N/A	N/A
Management		N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
Average Age, yrs.		N/A	N/A	N/A	N/A
Annual Turnover Rate %		N/A	N/A	N/A	N/A
Seniority, yrs.		N/A	N/A	N/A	N/A
Yrs. of Formal Education		N/A	N/A	N/A	N/A
Training, hrs./yr.		N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
Additional Remarks		N/A	N/A	N/A	N/A

The staff consists of approximately 3,000 civilians and 5,000 military personnel. Moderate to high turn-over can create problems in training staff and other user personnel about materials and procedures which would minimize waste generation.

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WORKSHEET 6

PROCESS INFORMATION

EPA

Process Unit/Operation: Non-destructive Inspection

Operation Type: ☐ Continuous ☐ Discrete ☐ Batch or Semi-Batch ☐ Other

Document	Status					
	Complete? (Y/N)	Current? (Y/N)	Last Revision	Used in this Report (Y/N)	Document Number	Location
Process Flow Diagram	Y			Y		
Material/Energy Balance	N					
Design						
Operating						
Flow/Amount Measurements	N					
Stream						
Analyses/Assays						
Stream						
Process Description	Y	Y		Y		
Operating Manuals	N					
Equipment List	N					
Equipment Specifications	N					
Piping & Instrument Diagrams	NA					
Plot and Elevation Plan(s)	NA					
Work Flow Diagrams	Y	Y		Y		
Hazardous Waste Manifests						
Emission Inventories						
Annual/Biennial Reports	N					
Environmental Audit Reports	N					
Permit/Permit Applications	N					
Batch Sheet(s)	N					
Materials Application Diagrams	N					
Product Composition Sheets	N					
Material Safety Data Sheets	Y	Y		Y		
Inventory Records	N					
Operator Logs	N					
Production Schedules	N					

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WORKSHEET 7

INPUT MATERIALS SUMMARY

EPA

Attribute	Description[1]		
	Stream No. 1	Stream No. 2	Stream No. 3
Name/ID	Penetrant ZL-22D	Emulsifier ZR-10A	Developer ZP-14
Source/Supplier	Magnaflux	Magnaflux	Magnaflux
Component/Attribute of Concern		20% ZR-10A	2 lb/gal ZP-14
Annual Consumption Rate			
Overall	410 lb		
Component(s) of Concern		328	400
Purchase Price, $ per lb	4.43	2.66	4.00
Overall Annual Cost	1820	870	1600
Delivery Mode[2]	truck	truck	truck
Shipping Container Size & Type[3]	55 gal. drum	55 gal. drum	50 lb bag
Storage Mode[4]			
Transfer Mode[5]			
Empty Container Disposal/Management[6]			
Shelf Life			
Supplier Would			
- accept expired material (Y/N)			
- accept shipping containers (Y/N)			
- revise expiration date (Y/N)			
Acceptable Substitute(s), if any			
Alternate Supplier(s)			

1 stream numbers, if applicable, should correspond to those used on process flow diagrams.
2 e.g., pipeline, tank car, 100 bbl. tank truck, truck, etc.
3 e.g., 55 gal. drum, 100 lb. paper bag, tank, etc.
4 e.g., outdoor, warehouse, underground, aboveground, etc.
5 e.g., pump, forklift, pneumatic transport, conveyor, etc.
6 e.g., crush and landfill, clean and recycle, return to supplier, etc.

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WORKSHEET 8

PRODUCTS SUMMARY

EPA

Attribute	Description[1]		
	Stream No.___	Stream No.___	Stream No.___
Name/ID	Inspected aircraft parts including C-9 wheel hubs		
Component/Attribute of Concern			
Annual Production Rate			
Overall			
Component(s) of Concern			
Annual Revenues, $ _____			
Shipping Mode			
Shipping Container Size & Type			
Onsite Storage Mode			
Containers Returnable (Y/N)			
Shelf Life			
Rework Possible (Y/N)			
Customer Would			
- relax specification (Y/N)			
- accept larger containers (Y/N)			

[1] stream numbers, if applicable, should correspond to those used on process flow diagrams.

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WORKSHEET 9a

INDIVIDUAL WASTE STREAM CHARACTERIZATION

EPA

1. **Waste Stream Name/ID:** Penetrant **Stream Number** 1
   Process Unit/Operation Non-destructive Inspection (NDI)

2. **Waste Characteristics** (attach additional sheets with composition data, as necessary.)

   ☐ gas ☒ liquid ☐ solid ☐ mixed phase

   Density, lb/cuft 61.3 High Heating Value, Btu/lb _____
   Viscosity/Consistency 7.7 cs
   pH Neutral ,Flash Point > 200°F ; % Water _____

3. **Waste Leaves Process as:**
   ☐ air emission ☐ waste water ☒ solid waste ☐ hazardous waste

4. **Occurrence**
   ☐ continuous _____
   ☒ discrete _____
   discharge triggered by ☐ chemical analysis _____
   ☒ other (describe) failure to pass sensitivity test
   Type: ☐ periodic _____ length of period: _____
   ☒ sporadic (irregular occurrence)
   ☐ non-recurrent

5. **Generation Rate**
   Annual 410 lbs per year
   Maximum _____ lbs per _____
   Average _____ lbs per _____
   Frequency 1 batches per 2-4 years
   Batch Size 410 lb average _____ range

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WORKSHEET 9b

INDIVIDUAL WASTE STREAM CHARACTERIZATION
(continued)

EPA

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? ☐ Yes ☒ No

Describe how the waste is generated.

Waste is generated by the accumulation of contaminants (i.e. carbon residu corrosion inhibitor, and oil & grease) in the penetrant tank during routine us Once contaminated, the used penetrant is transferred to 55 gallon drums and the penetrant tank is refilled with new penetrant. The penetrant is changed when it is significantly less sensitive when compared to new penetrant on test panels. Changing of the penetrant usually occurs every 2-4 years depending on frequency of use.

Example: **Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component (e.g., drag-out), equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, breathing or venting losses, etc.**

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WORKSHEET 9c

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

Waste Stream Penetrant

7. Management Method

Leaves site in

- ☐ bulk
- ☐ roll off bins
- ☒ 55 gal drums
- ☐ other (describe)

Disposal Frequency 100 gallons every 2 - 4 years

Applicable Regulations[1] RCRA

Regulatory Classification[2] The waste is handled as a D001 waste, but should not be considered as hazardous

Managed

- ☐ onsite
- ☒ offsite
- ☐ commercial TSDF Special Waste Inc., Athens, GA
- ☐ own TSDF
- ☐ other (describe)

Recycling

- ☐ direct use/re-use
- ☐ energy recovery
- ☐ redistilled
- ☐ other (describe)

reclaimed material returned to site?

☐ Yes ☐ No ☐ used by others

residue yield

residue disposal/repository

Note[1] list federal, state & local regulations, (e.g., RCRA, TSCA, etc.)

Note[2] list pertinent regulatory classification (e.g., RCRA - Listed K011 waste, etc.)

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WORKSHEET 9d

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

Waste Stream Penetrant

7. Management Method (continued)

Treatment

- ☐ biological
- ☐ oxidation/reduction
- ☒ incineration cement kiln
- ☐ pH adjustment
- ☐ precipitation
- ☐ solidification
- ☐ other (describe)

residue disposal/repository

Final Disposition

- ☐ landfill
- ☐ pond
- ☐ lagoon
- ☐ deep well
- ☐ ocean
- ☒ other (describe) cementitious product

Costs as of 3rd - 1990 (quarter and year)

Cost Element:	Unit Price $ per ____	Reference/Source:
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Local Taxes		
State Tax		
Federal Tax		
Total Disposal Cost	$3/gal.	Capt. Maria Lanctot

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WORKSHEET 9a

INDIVIDUAL WASTE STREAM CHARACTERIZATION

EPA

1. **Waste Stream Name/ID:** Emulsifier **Stream Number** 2
   Process Unit/Operation Non-destructive Inspection (NDI)

2. **Waste Characteristics** (attach additional sheets with composition data, as necessary.)

   ☐ gas ☒ liquid ☐ solid ☐ mixed phase

   Density, lb/cuft 62 High Heating Value, Btu/lb _____
   Viscosity/Consistency 12.5 cs
   pH 7 ,Flash Point >200°F ; % Water _____

3. **Waste Leaves Process as:**
   ☐ air emission ☐ waste water ☐ solid waste ☐ hazardous waste

4. **Occurrence**
   ☐ continuous _____
   ☒ discrete _____
   discharge triggered by ☐ chemical analysis _____
   ☒ other (describe) bi-annual cleaning of tank
   Type: ☒ periodic 1 length of period: 6 months
   ☐ aporadic (irregular occurrence)
   ☐ non-recurrent

5. **Generation Rate**
   Annual 328 lbs per year
   Maximum _____ lbs per _____
   Average _____ lbs per _____
   Frequency 2 batches per year
   Batch Size 164 lb. average _____ range

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WORKSHEET 9b

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? [X] Yes [ ] No

Describe how the waste is generated.

A 20% solution of emulsifier (ZR-10A) is used to remove excess penetrant from the surface of parts being inspected per the dye penetrant test. Parts are dipped in a tank of emulsifier. As part of the NDI shop procedures, the emulsion tank is emptied and cleaned out every six months. This emulsion solution is drained through a floor drain to a sewage lift station. After cleaning, the tank is filled with new emulsifier solution.

Example: Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component (e.g., drag-out), equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, breathing or venting losses, etc.

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WORKSHEET 9c

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

Waste Stream Emulsifier

7. Management Method

Leaves site in

- ☐ bulk
- ☐ roll off bins
- ☐ 55 gal drums
- ☐ other (describe)

Disposal Frequency

Applicable Regulations[1] None

Regulatory Classification[2] None

Managed

- ☒ onsite ☐ offsite
- ☐ commercial TSDF
- ☐ own TSDF
- ☐ other (describe)

Recycling

- ☐ direct use/re-use
- ☐ energy recovery
- ☐ redistilled
- ☐ other (describe)

reclaimed material returned to site?

☐ Yes ☐ No ☐ used by others

residue yield

residue disposal/repository

Note[1] list federal, state & local regulations, (e.g., RCRA, TSCA, etc.)

Note[2] list pertinent regulatory classification (e.g., RCRA - Listed K011 waste, etc.)

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WORKSHEET **9d**

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

Waste Stream Emulsifier

7. **Management Method (continued)**

Treatment

- ☐ biological
- ☐ oxidation/reduction
- ☐ incineration
- ☐ pH adjustment
- ☐ precipitation
- ☐ solidification
- ☒ other (describe) sewage treatment plant

residue disposal/repository

Final Disposition

- ☐ landfill
- ☐ pond
- ☐ lagoon
- ☐ deep well
- ☐ ocean
- ☐ other (describe)

Costs as of _____ (quarter and year)

Cost Element:	Unit Price $ per ____	Reference/Source:
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Local Taxes		
State Tax		
Federal Tax		
Total Disposal Cost		

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WORKSHEET 9a

INDIVIDUAL WASTE STREAM CHARACTERIZATION

EPA

1. Waste Stream Name/ID: Developer Stream Number 3
   Process Unit/Operation Non-destructive inspection (NDI)

2. Waste Characteristics (attach additional sheets with composition data, as necessary.)

   ☐ gas ☒ liquid ☐ solid ☐ mixed phase

   Density, lb/cuft 77 High Heating Value, Btu/lb _____
   Viscosity/Consistency _____
   pH 9.3 ,Flash Point NONE ; % Water 80

3. Waste Leaves Process as:

   ☐ air emission ☒ waste water ☐ solid waste ☐ hazardous waste

4. Occurrence

   ☐ continuous _____
   ☐ discrete _____
   discharge triggered by ☐ chemical analysis _____
   ☒ other (describe) biannual cleaning of tank
   Type: ☒ periodic 1 length of period: 6 months
   ☐ sporadic (irregular occurrence)
   ☐ non-recurrent

5. Generation Rate

   Annual 400 lbs per year
   Maximum _____ lbs per _____
   Average _____ lbs per _____
   Frequency 2 batches per year
   Batch Size 200 lb average _____ range

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WORKSHEET 9b

INDIVIDUAL WASTE STREAM CHARACTERIZATION
(continued)

EPA

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? [X] Yes [ ] No

Describe how the waste is generated.

Waste is generated by use of developer to indicate surface dicontinuities on parts inspected per penetrant dye test. Developer is emptied bi-annually as part of the NDI laboratory's housekeeping practices. The developer is discarded through floor drains to a sewage lift station in order to clean out the tank. After cleaning, the tank is refilled with new developer.

Example: Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component (e.g., drag-out), equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, breathing or venting losses, etc.

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WORKSHEET 9c

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

Waste Stream Developer

7. Management Method

Leaves site in
- ☐ bulk
- ☐ roll off bins
- ☐ 55 gal drums
- ☐ other (describe)

Disposal Frequency

Applicable Regulations[1] None as handled (should be handled as D007 Waste)

Regulatory Classification[2] Not handled as hazardous waste (should be handled as D007 Waste)

Managed
- ☒ onsite ☐ offsite
- ☐ commercial TSDF
- ☐ own TSDF
- ☐ other (describe)

Recycling
- ☐ direct use/re-use
- ☐ energy recovery
- ☐ redistilled
- ☐ other (describe)

reclaimed material returned to site?
- ☐ Yes ☐ No ☐ used by others

residue yield

residue disposal/repository

Note[1] list federal, state & local regulations, (e.g., RCRA, TSCA, etc.)

Note[2] list pertinent regulatory classification (e.g., RCRA - Listed K011 waste, etc.)

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WORKSHEET 9d

INDIVIDUAL WASTE STREAM CHARACTERIZATION
(continued)

EPA

Waste Stream Developer

7. Management Method (continued)

Treatment

- ☐ biological
- ☐ oxidation/reduction
- ☐ incineration
- ☐ pH adjustment
- ☐ precipitation
- ☐ solidification
- ☒ other (describe) sewage treatment plant

residue disposal/repository

Final Disposition

- ☐ landfill
- ☐ pond
- ☐ lagoon
- ☐ deep well
- ☐ ocean
- ☐ other (describe)

Costs as of _____ (quarter and year)

Cost Element:	Unit Price $ per ____	Reference/Source:
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Local Taxes		
State Tax		
Federal Tax		
Total Disposal Cost		

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WORKSHEET 10

WASTE STREAM SUMMARY

EPA

Attribute		Description[1]					
		Stream No. 1		Stream No. 2		Stream No. 3	
Waste ID/Name:		Penetrant ZL-22D		Emulsifier ZR-10A		Developer ZP-14	
Source/Origin		Magnaflux		Magnaflux		Magnaflux	
Component/or Property of Concern				20% ZR-10A		2 lb/gal ZP-14	
Annual Generation Rate (units lbs)							
Overall		410					
Component(s) of Concern				328		400	
Cost of Disposal							
Unit Cost ($ per: gal)		3.00					
Overall (per year)		150		negligible		negligible	
Method of Management[2]		Offsite incineration		Sewage Treatment Plant		Sewage Treatment Plant	
Priority Rating Criteria[3]	Relative Wt. (W)	Rating (R)	R x W	Rating (R)	R x W	Rating (R)	R x W
Regulatory Compliance	10	0	0	0	0	10	100
Treatment/Disposal Cost	5	3	15	0	0	5	25
Potential Liability	7	2	14	2	14	8	56
Waste Quantity Generated	6	4	24	4	24	7	42
Waste Hazard	9	1	9	1	9	9	81
Safety Hazard	9	2	18	1	9	8	72
Minimization Potential	7	2	14	2	14	7	49
Potential to Remove Bottleneck	1	0	0	0	0	0	0
Potential By-product Recovery	5	0	0	4	20	2	10
Sum of Priority Rating Scores		Σ(R x W)	94	Σ(R x W)	90	Σ(R x W)	435
Priority Rank		2		3		1	

Notes: 1. Stream numbers, if applicable, should correspond to those used on process flow diagrams.

2. For example, sanitary landfill, hazardous waste landfill, onsite recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.

3. Rate each stream in each category on a scale from 0 (none) to 10 (high).

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WORKSHEET 11

OPTION GENERATION

EPA

Meeting format (e.g., brainstorming, nominal group technique) brainstorming session

Meeting Coordinator G. E. Baker

Meeting Participants G. E. Baker, G. C. Wahl

List Suggested Options	Rationale/Remarks on Option
1. Modify Eddy-current Equipment	Equipment could possibly be modified to handle complete inspection with the purchase of special attachments
2. Modify standard operating practice (SOP) for change-out of emulsifier and developer.	Would need minor tank modifications and a comprehensive QA/QC program. Batch life of emulsifier and developer could be extended.
3. Switch to silica-based dry developer.	This developer does not result in the generation of hazardous waste.

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WORKSHEET 12

OPTION DESCRIPTION

EPA

Option Name: Modify Eddy-current Equipment

Briefly describe the option An Option previously investigated by the USAF involved purchasing special attachments for the Eddy-current tester to allow it to perform the complete inspection. If areas other than the bead seat area could be inspected by eddy-current, the need for NDI inspection of wheels would be eliminated. This equipment modification would be expensive. A new test procedure would need to be developed and approved by the wheel manufacturer.

Waste Stream(s) Affected: Penetrant, Emulsifier, Developer

Input Material(s) Affected: Penetrant, Emulsifier, Developer

Product(s) Affected: May affect quality of wheels if new procedures has flaws or equipment develops problems.

Indicate Type:

- [X] **Source Reduction**
  - X **Equipment-Related Change**
  - ___ **Personnel/Procedure-Related Change**
  - ___ **Materials-Related Change**
- [ ] **Recycling/Reuse**
  - ___ **Onsite**
  - ___ **Offsite**
  - ___ **Material reused for original purpose**
  - ___ **Material used for a lower-quality purpose**
  - ___ **Material sold**
  - ___ **Material burned for heat recovery**

Originally proposed by: USAF **Date:** ____

Reviewed by: Gary E. Baker **Date:** ____

Approved for study? X **yes** ____ **no, by:** ____

Reason for Acceptance or Rejection Only a simplified WM assessment was performed due to the unfavorable payback period.

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WORKSHEET 12

OPTION DESCRIPTION

EPA

Option Name: Modify SOP for change-out of emulsifier and developer

Briefly describe the option Complete change-out of the emulsifier and developer would be based on effectiveness rather than routine biannual cleaning. A test program such as Magnaflux PeneCert Service would be needed to certify the quality of the solutions and trend results. With adequate QA/QC program the batch life of emulsifier and developer could be extended by installing a drain and skimming off the top portions of the tanks. Could drain 25% of tank every six months and completely drain and clean tank every two years.

Waste Stream(s) Affected: Less emulsifier and developer waste generated.

Input Material(s) Affected: Should use less emulsifier and developer

Product(s) Affected: Should not affect inspection of parts as long as emulsifier and developer solutions are certified.

Indicate Type:

- [X] Source Reduction
  - X Equipment-Related Change
  - X Personnel/Procedure-Related Change
  - __ Materials-Related Change
- [ ] Recycling/Reuse
  - __ Onsite
  - __ Offsite
  - __ Material reused for original purpose
  - __ Material used for a lower-quality purpose
  - __ Material sold
  - __ Material burned for heat recovery

Originally proposed by: G. Baker/G. Wahl **Date:** 11-6-90

Reviewed by: G. Baker **Date:** __

Approved for study? X yes ____ no, **by:** G. Baker

Reason for Acceptance or Rejection Low capital cost - High probability of success

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WORKSHEET 12

OPTION DESCRIPTION

EPA

Option Name: Switch to silica - based dry developer

Briefly describe the option The wet developer containing sodium chromate could be replaced with a non-hazardous silica based dry developer (ZP-4B) from the same supplier. The supplier claims the use of dry developer would not reduce the sensitivity of the NDI test. The dry developer would be applied by spray nozzles in a dyamic cloud chamber. A 1 hp dust collector would evacuate the chamber during and after developer application. The amount of developer used would be reduced but the cost per pound would be somewhat higher.

Waste Stream(s) Affected: Developer waste would no longer be hazardous.

Input Material(s) Affected: Developer would be silica - based instead of containing sodium chromate.

Product(s) Affected: May result in a more sensitive inspection because of a more uniformed coating of developer.

Indicate Type:

- [X] **Source Reduction**
  - ___ **Equipment-Related Change**
  - ___ **Personnel/Procedure-Related Change**
  - X **Materials-Related Change**
- [ ] **Recycling/Reuse**
  - ___ **Onsite** ___ **Material reused for original purpose**
  - ___ **Offsite** ___ **Material used for a lower-quality purpose**
  - ___ **Material sold**
  - ___ **Material burned for heat recovery**

Originally proposed by: G. Baker/G. Wahl **Date:** 11-6-90

Reviewed by: G. Baker **Date:** ___

Approved for study? ___ **yes** X **no, by:** ___

Reason for Acceptance or Rejection Only a simplified WM assessment was performed due to the unfavorable payback period.

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WORKSHEET 13

OPTIONS EVALUATION BY WEIGHTED SUM METHOD

EPA

Criteria	Weight (W)	Options Rating (R)									
		#1 Option Modify Eddy-current		#2 Option Modify SOP		#3 Option Dry Developer		#4 Option		#5 Option	
		R	R x W	R	R x W	R	R x W	R	R x W	R	R x W
Reduction in waste's hazard	9	10	90	0	0	8	72				
Reduction of treatment/disposal costs	6	10	60	7	42	7	42				
Reduction of safety hazards	7	10	70	0	0	5	35				
Reduction of input material costs	5	10	50	6	30	4	20				
Extent of current use in industry	4	2	8	7	28	8	32				
Effect on product quality (no effect = 10)	10	5	50	10	100	10	100				
Low capital cost	9	1	9	10	90	2	18				
Low O & M cost	8	6	48	10	80	3	24				
Short implementation period	5	6	30	10	50	3	15				
Ease of implementation	7	5	35	10	70	4	28				
Final Evaluation: Sum of Weighted Ratings Σ (W x R)		450		490		386					
Final Evaluation: Option Ranking		2		1		3					
Feasibility Analysis Scheduled for (Date)											

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WORKSHEET 14a

TECHNICAL FEASIBILITY

EPA

WM Option Description Modify Eddy-current Equipment

1. **Nature of WM Option**
   - [X] Equipment-Related
   - [ ] Personnel/Procedure-Related
   - [ ] Materials-Related

2. **If the option appears technically feasible, state your rationale for this.** Eddy-current, like penetrant inspection, is used to detect surface flaws.

Is further analysis required? [ ] Yes [ ] No. **If yes, continue with this worksheet. If not, skip to worksheet 15.**

3. **Equipment - Related Option**

	YES	NO	
Equipment available commercially?	[X]	[ ]	
Demonstrated commercially?	[X]	[ ]	
In similar application?	[X]	[ ]	
Successfully?	[X]	[ ]	

Describe closest industrial analog Some airlines use a robotic system to eddy-current the entire wheel. Not sure if penetrant test has been eliminated though.

Describe status of development Not approved method by the manufacter of the wheels at Scott AFB. Mil Specs would need to be changed.

Prospective Vendor	Working Installation(s)	Contact Person(s)	Date Contacted 1.

1. **Also attach filled out phone conversation notes, installation visit report, etc.**

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WORKSHEET 14b

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Modify Eddy-Current Equipment

3. **Equipment-Related Option (continued)**

Performance information required (describe parameters): _____

Scaleup information required (describe): _____

Testing Required: ☐ yes ☐ no

Scale: ☐ bench ☐ pilot ☐ _____

Test unit available? ☐ yes ☐ no _____

Test Parameters (list) _____

Number of test runs: _____

Amount of material(s) required: _____

Testing to be conducted: ☐ In-plant

☐ _____

Facility/Product Constraints:

Space Requirements _____

Possible locations within facility _____

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WORKSHEET 14c

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Modify Eddy-current Equipment

2. Equipment-Related Option (continued)

Utility Requirements:

Electric Power	Volts (AC or DC) _____	kW _____
Process Water	Flow _____	Pressure _____
	Quality (tap, demin, etc.) _____	
Cooling Water	Flow _____	Pressure _____
	Temp. In _____	Temp. Out _____
Coolant/Heat Transfer Fluid	_____	
	Temp. In _____	Temp. Out _____
	Duty _____	
Steam	Pressure _____	Temp. _____
	Duty _____	Flow _____
Fuel	Type _____	Flow _____
		Duty _____
Plant Air	_____	Flow _____
Inert Gas	_____	Flow _____

Estimated delivery time (after award of contract) _____

Estimated installation time _____

Installation dates _____

Estimated production downtime _____

Will production be otherwise affected? Explain the effect and impact on production. _____

Will product quality be affected? Explain the effect on quality. _____

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WORKSHEET 14d

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Modify Eddy-current Equipment

3. Equipment-Related Option (continued)

Will modifications to work flow or production procedures be required? Explain.

Operator and maintenance training requirements

Number of people to be trained ☐ Onsite ☐ Offsite

Duration of training

Describe catalyst, chemicals, replacement parts, or other supplies required.

Item	Rate or Frequency of Replacement	Supplier, Address

Does the option meet government and company safety and health requirements?

☐ Yes ☐ No Explain

How is service handled (maintenance and technical assistance)? Explain

What warranties are offered?

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WORKSHEET 14e

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Modify Eddy-Current Equipment

3. Equipment-Related Option (continued)

Describe any additional storage or material handling requirements.

Describe any additional laboratory or analytical requirements.

4. Personnel/Procedure-Related Changes

Affected Departments/Areas NDI Shop

Training Requirements Personnel operating the eddy-current equipment will have to familiarize themselves with attachments

Operating Instruction Changes. Describe responsible departments.

5. Materials-Related Changes (Note: If substantial changes in equipment are required, then handle the option as an equipment-related one.)

	Yes	No
Has the new material been demonstrated commercially?	☐	☐
In a similar application?	☐	☐
Successfully?	☐	☐

Describe closest application.

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WORKSHEET 14f

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Modify Eddy-current Equipment

4. **Materials-Related Changes (continued)**

Affected Departments/Areas _____

Will production be affected? Explain the effect and impact on production.

Will product quality be affected? Explain the effect and the impact on product quality.

Will additional storage, handling or other ancillary equipment be required? Explain.

Describe any training or procedure changes that are required.

Decribe any material testing program that will be required.

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WORKSHEET 15a

COST INFORMATION

EPA

WM Option Description: Modify Eddy-current Equipment

CAPITAL COSTS - Include all costs as appropriate.		TOTALS
[X] Purchased Process Equipment		
Price (fob factory)		
Taxes, freight, insurance		
Delivered equipment cost		
Price for Initial Spare Parts Inventory		$70,000 reported by O. Robison
[ ] Estimated Materials Cost		
Piping		
Electrical		
Instruments		
Structural		
Insulation/Piping		
[ ] Estimated Costs for Utility Connections and New Utility Systems		
Electricity		
Steam		
Cooling Water		
Process Water		
Refrigeration		
Fuel (Gas or Oil)		
Plant Air		
Inert Gas		
[ ] Estimated Costs for Additional Equipment		
Storage & Material Handling		
Laboratory/Analytical		
Other		
[ ] Site Preparation		
(Demolition, site clearing, etc.)		
[ ] Estimated Installation Costs		
Vendor		
Contractor		
In-house Staff		

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WORKSHEET 15b

COST INFORMATION
(continued)

EPA

CAPITAL COSTS (Cont.) — **TOTALS**

☐ **Engineering and Procurement Costs (In-house & outside)**

- Planning _____
- Engineering _____
- Procurement _____
- Consultants _____ _____

☐ **Start-up Costs**

- Vendor _____
- Contractor _____
- In-house _____ _____

☐ **Training Costs** _____ _____

☐ **Permitting Costs**

- Fees _____
- In-house Staff Costs _____ _____

☐ **Initial Charge of Catalysts and Chemicals**

- Item #1 _____
- Item #2 _____ _____

☐ **Working Capital** [Raw Materials, Product, Inventory, Materials and Supplies (not elsewhere specified)].

- Item #1 _____
- Item #2 _____
- Item #3 _____
- Item #4 _____ _____

☐ **Estimated Salvage Value (If any)** _____

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WORKSHEET 15c

COST INFORMATION

(continued)

EPA

CAPITAL COST SUMMARY

Cost Item	Cost
Purchased Process Equipment	$70,000
Materials	
Utility Connections	
Additional Equipment	
Site Preparation	
Installation	
Engineering and Procurement	
Start-up Cost	
Training Costs	
Permitting Costs	
Initial Charge of Catalysts and Chemicals	
Fixed Capital Investment	
Working Capital	
Total Capital Investment	
Salvage Value	

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WORKSHEET 15d

COST INFORMATION (continued)

EPA

☐ **Estimated Decrease (or Increase) in Utilities**

Utility	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time
Electricity			
Steam			
Cooling Process			
Process Water			
Refrigeration			
Fuel (Gas or Oil)			
Plant Air			
Inert Air			

INCREMENTAL OPERATING COSTS - Include all relevant operating savings. Estimate these costs on an incremental basis (i.e., as decreases or increases over existing costs).

☒ **BASIS FOR COSTS** Annual X Quarterly ____ Monthly ____ Daily ____ Other____

☒ **Estimated Disposal Cost Saving**

Decrease in TSDF Fees	150
Decrease in State Fees and Taxes	
Decrease in Transportation Costs	
Decrease in Onsite Treatment and Handling	
Decrease in Permitting, Reporting and Recordkeeping	
Total Decrease in Disposal Costs	

☒ **Estimated Decrease in Raw Materials Consumption**

Materials	Unit Cost $ per unit	Reduction in Quantity Units per time	Decrease in Cost $ per time
Penetrant 2L-22D	4.43/lb	410 lb	1816
Emulsifier 2R-10A	2.66/lb	328 lb	872
Developer 2P-14	4.00/lb	400 lb	1600

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WORKSHEET 15e

COST INFORMATION

(continued)

EPA

☐ **Estimated Decrease (or Increase) in Ancillary Catalysts and Chemicals**

Catalyst/Chemical	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time

☐ **Estimated Decrease (or Increase) in Operating Costs and Maintenance Labor Costs (Include cost of supervision, benefits and burden).**

☐ **Estimated Decrease (or Increase) in Operating and Maintenance Supplies and Costs.**

☐ **Estimated Decrease (or Increase) in Insurance and Liability Costs (explain).**

☐ **Estimated Decrease (or Increase) in Other Operating Costs (explain).**

INCREMENTAL REVENUES

☐ **Estimated Incremental Revenues from an Increase (or Decrease) in Production or Marketable By-products (explain).**

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WORKSHEET 15 f

COST INFORMATION

(continued)

EPA

INCREMENTAL OPERATING COST AND REVENUE SUMMARY (ANNUAL BASIS)

Decreases in Operating Cost or Increases in Revenue are Positive.
Increases in Operating Cost or Decrease in Revenue are Negative.

Operating Cost/Revenue Item	$ per year
Decrease in Disposal Cost	150
Decrease in Raw Materials Cost	4290
Decrease (or Increase) in Utilities Cost	
Decrease (or Increase) in Catalysts and Chemicals	
Decrease (or Increase) in O & M Labor Costs	
Decrease (or Increase) in O & M Supplies Costs	
Decrease (or Increase) in Insurance/Liabilities Costs	
Decrease (or Increase) in Other Operating Costs	
Incremental Revenues from Increased (Decreased) Production	
Incremental Revenues from Marketable By-products	
Net Operating Cost Savings	4440

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WORKSHEET 16

PROFITABILITY WORKSHEET # 1 PAYBACK PERIOD

EPA

Total Capital Investment ($) (from Worksheet 15c) $70,000 (reported by O. Robison)

Annual Net Operating Cost Savings ($ per year) (from Worksheet 15f) 4440

Payback Period (in years) = $\frac{\text{Total Capital Investment}}{\text{Annual Net Operating Cost Savings}}$ = 15.8

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WORKSHEET 14a

TECHNICAL FEASIBILITY

EPA

WM Option Description Modify SOP for change-out of emulsifier and developer

1. **Nature of WM Option**
   - [X] Equipment-Related
   - [X] Personnel/Procedure-Related
   - [ ] Materials-Related

2. **If the option appears technically feasible, state your rationale for this.** The supplier stated that with a proper test program continual make-up should be the standard operating practice for extending the life of the baths.

Is further analysis required? [X] Yes [ ] No. **If yes, continue with this worksheet. If not, skip to worksheet 15.**

3. **Equipment - Related Option**

	YES	NO	
Equipment available commercially?	[X]	[ ]	
Demonstrated commercially?	[X]	[ ]	
In similar application?	[X]	[ ]	
Successfully?	[X]	[ ]	

Describe closest industrial analog

Describe status of development The normal procedure should be to continually make-up until too much penetrant is present. A portable refractometer is usually used to measure penetrant contamination.

Prospective Vendor	Working Installation(s)	Contact Person(s)	Date Contacted 1.
Magnaflux		Velima Holmogren	11-6-90
		Sei Song	
		(708) 867-3385	

1. Also attach filled out phone conversation notes, installation visit report, etc.

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WORKSHEET 14b

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Modify SOP for change-out of emulsifier and developer

3. Equipment-Related Option (continued)

Performance information required (describe parameters):

Scaleup information required (describe):

Testing Required: [X] yes [ ] no

Scale: [ ] bench [ ] pilot [ ] Full scale with existing tanks

Test unit available? [ ] yes [ ] no Not required

Test Parameters (list) The option requires initiating a test program such as Magnaflux's PeneCert Program. The supplier could analyze the products for any applicable parameters and certify the quality.

Number of test runs: Trial period should last 24 months

Amount of material(s) required:

Testing to be conducted: [X] In-plant

[ ] Analysis by USAF or supplier

Facility/Product Constraints:

Space Requirements Need 12 inch clearance on a side of each tank

Possible locations within facility Use existing NDI shops

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WORKSHEET 14c

TECHNICAL FEASIBILITY

(continued)

EPA

WM Option Description Modify SOP for change-out of emulsifier and developer

2. Equipment-Related Option (continued)

Utility Requirements:

Electric Power — Volts (AC or DC) _____ kW _____

Process Water — Flow _____ Pressure _____

Quality (tap, demin, etc.) _____

Cooling Water — Flow _____ Pressure _____

Temp. In _____ Temp. Out _____

Coolant/Heat Transfer Fluid _____

Temp. In _____ Temp. Out _____

Duty _____

Steam — Pressure _____ Temp. _____

Duty _____ Flow _____

Fuel — Type _____ Flow _____

Duty _____

Plant Air _____ Flow _____

Inert Gas _____ Flow _____

Estimated delivery time (after award of contract) _____

Estimated installation time 2 days

Installation dates _____

Estimated production downtime 2 days

Will production be otherwise affected? Explain the effect and impact on production. Should not affect operation. Downtime could be reduced since skimming the top would be easier than draining and cleaning baths. Sampling should not slow down operation.

Will product quality be affected? Explain the effect on quality. Quality will not deteriorate because a stringent QA/QC test program will be in place. Operators will have monthly reports on the condition of each bath and be able to monitor and identify problems.

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
Date 12-17-90	Proj. No. 1-832-03-200-30	Sheet 4 of 6 Page __ of __

WORKSHEET 14d

TECHNICAL FEASIBILITY

(continued)

EPA

WM Option Description Modify SOP for change-out of emulsifier and developer

3. Equipment-Related Option (continued)

Will modifications to work flow or production procedures be required? Explain. Clean-out of the emulsifier and developer is currently done every 6 months. With this option, it would be changed to every 2 years with partial make-up occuring every 6 months. Product testing by supplier could replace current test method and determine need to change penetrant.

Operator and maintenance training requirements

Number of people to be trained _____ [X] Onsite [ ] Offsite

Duration of training _____

Describe catalyst, chemicals, replacement parts, or other supplies required.

Item	Rate or Frequency of Replacement	Supplier, Address
Sample Kit	Monthly	Magnaflux

Does the option meet government and company safety and health requirements?

[X] Yes [ ] No **Explain** _____

How is service handled (maintenance and technical assistance)? Explain _____

What warranties are offered? Supplier will certify in writing products have met applicable requirements if they perform the analysis.

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 14e

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Modify SOP for change-out of emulsifier and developer

3. **Equipment-Related Option (continued)**

Describe any additional storage or material handling requirements. May have to store waste longer onsite before sufficient quantities are collected to fill 55 gallon drums. It is anticipated that the current methods for waste handling may change since developer is a D007 waste.

Describe any additional laboratory or analytical requirements. Sample kits would need to be obtained. QA/QC analysis would be performed by either USAF or supplier.

4. **Personnel/Procedure-Related Changes**

Affected Departments/Areas NDI Shop

Training Requirements Operators would need to be trained on proper sampling techiques and procedures for skimming off contaminants and making up with the correct concentration of new product.

Operating Instruction Changes. Describe responsible departments. NDI Shop

5. **Materials-Related Changes (Note: If substantial changes in equipment are required, then handle the option as an equipment-related one.)**

	Yes	No
Has the new material been demonstrated commercially?	☐	☐
In a similar application?	☐	☐
Successfully?	☐	☐

Describe closest application.

Firm USAF	**Waste Minimization Assessment**	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15a

COST INFORMATION

EPA

WM Option Description Modify SOP for change-out of emulsifier and developer

CAPITAL COSTS - Include all costs as appropriate.

		TOTALS
☐ **Purchased Process Equipment**		
Price (fob factory)		
Taxes, freight, insurance		
Delivered equipment cost		
Price for initial Spare Parts inventory		
☒ **Estimated Materials Cost**		
Piping	$150	
Electrical		
Instruments		
Structural		
Insulation/Piping		$150
☐ **Estimated Costs for Utility Connections and New Utility Systems**		
Electricity		
Steam		
Cooling Water		
Process Water		
Refrigeration		
Fuel (Gas or Oil)		
Plant Air		
Inert Gas		
☐ **Estimated Costs for Additional Equipment**		
Storage & Material Handling		
Laboratory/Analytical		
Other		
☐ **Site Preparation**		
(Demolition, site clearing, etc.)		
☒ **Estimated Installation Costs**		
Vendor		
Contractor		
In-house Staff	4 hours at $15/hour	$60

Firm USAF	**Waste Minimization Assessment**	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15b

COST INFORMATION (continued)

EPA

CAPITAL COSTS (Cont.) — **TOTALS**

☒ **Engineering and Procurement Costs (In-house & outside)**

Planning	1 hour at $20/hour	
Engineering	4 hours at $25/hour	
Procurement		
Consultants		$120

☐ **Start-up Costs**

Vendor		
Contractor		
In-house		

☐ **Training Costs**

☐ **Permitting Costs**

Fees		
In-house Staff Costs		

☐ **Initial Charge of Catalysts and Chemicals**

Item #1		
Item #2		

☐ **Working Capital [Raw Materials, Product, Inventory, Materials and Supplies (not elsewhere specified)].**

Item #1		
Item #2		
Item #3		
Item #4		

☐ **Estimated Salvage Value (if any)**

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15c

COST INFORMATION

(continued)

EPA

CAPITAL COST SUMMARY

Cost Item	Cost
Purchased Process Equipment	
Materials	$150
Utility Connections	
Additional Equipment	
Site Preparation	
Installation	$60
Engineering and Procurement	$120
Start-up Cost	
Training Costs	
Permitting Costs	
Initial Charge of Catalysts and Chemicals	
Fixed Capital Investment	
Working Capital	
Total Capital Investment	$330
Salvage Value	

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site ~~Scott AFB, IL~~	Proc. Unit/Oper. NDI	Checked By G.E. Baker
Date 12/17/90	Proj. No. 1-832-03-200-30	Sheet 4 of 6 Page __ of __

WORKSHEET 15d

COST INFORMATION

(continued)

EPA

☐ **Estimated Decrease (or Increase) in Utilities**

Utility	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time
Electricity			
Steam			
Cooling Process			
Process Water			
Refrigeration			
Fuel (Gas or Oil)			
Plant Air			
Inert Air			

INCREMENTAL OPERATING COSTS - Include all relevant operating savings. Estimate these costs on an incremental basis (i.e., as decreases or increases over existing costs).

☐ **BASIS FOR COSTS** Annual _____ Quarterly _____ Monthly _____ Daily _____ Other_____

☐ **Estimated Disposal Cost Saving**

Decrease in TSDF Fees _____

Decrease in State Fees and Taxes _____

Decrease in Transportation Costs _____

Decrease in Onsite Treatment and Handling _____

Decrease in Permitting, Reporting and Recordkeeping _____

Total Decrease in Disposal Costs _____

☐ **Estimated Decrease in Raw Materials Consumption**

Materials	Unit Cost $ per unit	Reduction in Quantity Units per time	Decrease in Cost $ per time
ZR-10A	$21.82/gal	45 gal/2 yrs.	$982/2 yrs.
ZP-14	$ 4/lb	450lb/2 yrs.	$1800/2 yrs.

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wah
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15e

COST INFORMATION

(continued)

EPA

☐ **Estimated Decrease (or Increase) in Ancillary Catalysts and Chemicals**

Catalyst/Chemical	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time

☒ **Estimated Decrease (or Increase) in Operating Costs and Maintenance Labor Costs (Include cost of supervision, benefits and burden).**

No significant change. Labor costs may be slightly less due to the fact the emulsifier and developer tanks would be scrubbed out half as often.

☒ **Estimated Decrease (or Increase) in Operating and Maintenance Supplies and Costs.**

May have to have a spare valve for the blow down lines on the emulsifier and developer tanks. It is anticipated this would already be a miscellaneous stock item however.

☐ **Estimated Decrease (or Increase) in Insurance and Liability Costs (explain).**

☐ **Estimated Decrease (or Increase) in Other Operating Costs (explain).**

INCREMENTAL REVENUES

☐ **Estimated Incremental Revenues from an Increase (or Decrease) in Production or Marketable By-products (explain).**

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15 f

COST INFORMATION

(continued)

EPA

INCREMENTAL OPERATING COST AND REVENUE SUMMARY (ANNUAL BASIS)

Decreases in Operating Cost or Increases in Revenue are Positive.
Increases in Operating Cost or Decrease in Revenue are Negative.

Operating Cost/Revenue Item	$ per year
Decrease in Disposal Cost	0
Decrease in Raw Materials Cost	$1391
Decrease (or Increase) in Utilities Cost	0
Decrease (or Increase) in Catalysts and Chemicals	0
Decrease (or Increase) in O & M Labor Costs	0
Decrease (or Increase) in O & M Supplies Costs	0
Decrease (or Increase) in Insurance/Liabilities Costs	0
Decrease (or Increase) in Other Operating Costs	0
Incremental Revenues from Increased (Decreased) Production	0
Incremental Revenues from Marketable By-products	0
Net Operating Cost Savings	$1391

Firm USAF	**Waste Minimization Assessment**	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 16

PROFITABILITY WORKSHEET # 1 PAYBACK PERIOD

EPA

Total Capital Investment ($) (from Worksheet 15c) 330

Annual Net Operating Cost Savings ($ per year) (from Worksheet 15f) 1391

Payback Period (in years) = $\frac{\text{Total Capital Investment}}{\text{Annual Net Operating Cost Savings}}$ = .24

NOTE: This does not include the cost for testing since it is assumed that such a program is needed regardless of the decision to use this option.

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
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WORKSHEET 14a

TECHNICAL FEASIBILITY

EPA

WM Option Description Switch to Dry Developer

1. **Nature of WM Option**
   - [ ] Equipment-Related
   - [ ] Personnel/Procedure-Related
   - [X] Materials-Related

2. **If the option appears technically feasible, state your rationale for this.** Magnaflux claims that dry developing has replaced wet developing for most new systems.

Is further analysis required? [X] Yes [ ] No. **If yes, continue with this worksheet. If not, skip to worksheet 15.**

3. **Equipment - Related Option**

	YES	NO	
Equipment available commercially?	[X]	[ ]	
Demonstrated commercially?	[X]	[ ]	
In similar application?	[X]	[ ]	
Successfully?	[X]	[ ]	

Describe closest industrial analog Magnaflux systems using ZP-4B developer

Describe status of development Meets same specifications as the wet developer (ZP-14) presently in use at Scott AFB

Prospective Vendor	Working Installation(s)	Contact Person(s)	Date Contacted 1.
Magnaflux	Yes	Don Bean	12/14/90

1. **Also attach filled out phone conversation notes, installation visit report, etc.**

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G. E. Baker
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WORKSHEET 14b

TECHNICAL FEASIBILITY
(continued)

EPA

WM Option Description: Switch to Dry Developer

3. Equipment-Related Option (continued)

Performance information required (describe parameters): _____

Scaleup information required (describe): _____

Testing Required: ☐ yes ☒ no

Scale: ☐ bench ☐ pilot ☐ _____

Test unit available? ☐ yes ☐ no _____

Test Parameters (list) _____

Number of test runs: _____

Amount of material(s) required: _____

Testing to be conducted: ☐ in-plant

☐ _____

Facility/Product Constraints:

Space Requirements _____

Possible locations within facility: In current dye penetrant process line between dryer and inspection booth.

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 14c

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Switch to Dry Developer

2. Equipment-Related Option (continued)

Utility Requirements:

Electric Power	Volts (AC or DC) 120V AC or 220V AC	kW
Process Water	Flow	Pressure
	Quality (tap, demin, etc.)	
Cooling Water	Flow	Pressure
	Temp. In	Temp. Out
Coolant/Heat Transfer Fluid		
	Temp. In	Temp. Out
	Duty	
Steam	Pressure	Temp.
	Duty	Flow
Fuel	Type	Flow
		Duty
Plant Air		Flow
Inert Gas		Flow

Estimated delivery time (after award of contract)

Estimated installation time

Installation dates

Estimated production downtime

Will production be otherwise affected? Explain the effect and impact on production.

Will product quality be affected? Explain the effect on quality. Should not effect sensitivity adversely. May be more sensitive because a more uniform and consistent layer of developer can be applied.

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 14d

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Switch to Dry Developer

3. Equipment-Related Option (continued)

Will modifications to work flow or production procedures be required? Explain.
The dryer will need to be moved to follow the emulsifier rinse and preceed the application of developer

Operator and maintenance training requirements

Number of people to be trained _____ ☐ Onsite

_____ ☐ Offsite

Duration of training

Describe catalyst, chemicals, replacement parts, or other supplies required.

Item	Rate or Frequency of Replacement	Supplier, Address

Does the option meet government and company safety and health requirements?

☒ Yes ☐ No Explain _____

How is service handled (maintenance and technical assistance)? Explain _____

What warranties are offered? _____

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
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WORKSHEET 14e

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Switch to Dry Developer

3. Equipment-Related Option (continued)

Describe any additional storage or material handling requirements.

Describe any additional laboratory or analytical requirements.

4. Personnel/Procedure-Related Changes

Affected Departments/Areas NDI Shop

Training Requirements

Operating Instruction Changes. Describe responsible departments.

5. Materials-Related Changes (Note: If substantial changes in equipment are required, then handle the option as an equipment-related one.)

	Yes	No
Has the new material been demonstrated commercially?	X	
In a similar application?	X	
Successfully?	X	

Describe closest application. Magnaflux system using ZP-4B developer

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E.Baker
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WORKSHEET 14f

TECHNICAL FEASIBILITY (continued)

EPA

WM Option Description Switch to Dry Developer

4. Materials-Related Changes (continued)

Affected Departments/Areas NDI Shop

Will production be affected? Explain the effect and impact on production.

Will product quality be affected? Explain the effect and the impact on product quality.
Should not affect sensitivity adversely. May be more sensitive becau
a more uniform and consistent layer of developer can be applied.

Will additional storage, handling or other ancillary equipment be required? Explain.

Describe any training or procedure changes that are required.

Decribe any material testing program that will be required.

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15a

COST INFORMATION

EPA

WM Option Description: Switch to Dry Developer

CAPITAL COSTS - Include all costs as appropriate.		TOTALS
[X] Purchased Process Equipment		
Price (fob factory)		
Taxes, freight, insurance		
Delivered equipment cost		
Price for Initial Spare Parts Inventory		11,000
[ ] Estimated Materials Cost		
Piping		
Electrical		
Instruments		
Structural		
Insulation/Piping		
[ ] Estimated Costs for Utility Connections and New Utility Systems		
Electricity		
Steam		
Cooling Water		
Process Water		
Refrigeration		
Fuel (Gas or Oil)		
Plant Air		
Inert Gas		
[ ] Estimated Costs for Additional Equipment		
Storage & Material Handling		
Laboratory/Analytical		
Other		
[ ] Site Preparation		
(Demolition, site clearing, etc.)		
[ ] Estimated Installation Costs		
Vendor		
Contractor		
In-house Staff		

Firm USAF	**Waste Minimization Assessment**	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15b

COST INFORMATION
(continued)

EPA

CAPITAL COSTS (Cont.) — **TOTALS**

☐ **Engineering and Procurement Costs (In-house & outside)**
- Planning _____
- Engineering _____
- Procurement _____
- Consultants _____ _____

☐ **Start-up Costs**
- Vendor _____
- Contractor _____
- In-house _____ _____

☐ **Training Costs** _____ _____

☐ **Permitting Costs**
- Fees _____
- In-house Staff Costs _____ _____

☐ **Initial Charge of Catalysts and Chemicals**
- Item #1 _____
- Item #2 _____ _____

☐ **Working Capital** [Raw Materials, Product, Inventory, Materials and Supplies (not elsewhere specified)].
- Item #1 _____
- Item #2 _____
- Item #3 _____
- Item #4 _____ _____

☐ **Estimated Salvage Value (If any)** _____

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
Site Scott AFB, IL	Proc. Unit/Oper. NDI	Checked By G.E. Baker
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WORKSHEET 15c

COST INFORMATION (continued)

EPA

CAPITAL COST SUMMARY

Cost Item	Cost
Purchased Process Equipment	
Materials	
Utility Connections	
Additional Equipment	
Site Preparation	
Installation	
Engineering and Procurement	
Start-up Cost	
Training Costs	
Permitting Costs	
Initial Charge of Catalysts and Chemicals	
Fixed Capital Investment	
Working Capital	
Total Capital Investment	$11,000
Salvage Value	

Firm	USAF	Waste Minimization Assessment		Prepared By	G.C. Wahl
Site	Scott AFB, IL	Proc. Unit/Oper.	NDI	Checked By	G.E. Baker
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WORKSHEET 15d

COST INFORMATION

(continued)

EPA

☐ **Estimated Decrease (or Increase) in Utilities**

Utility	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time
Electricity			
Steam			
Cooling Process			
Process Water			
Refrigeration			
Fuel (Gas or Oil)			
Plant Air			
Inert Air			

INCREMENTAL OPERATING COSTS - Include all relevant operating savings. Estimate these costs on an incremental basis (i.e., as decreases or increases over existing costs).

☐ **BASIS FOR COSTS** Annual ____ Quarterly ____ Monthly ____ Daily ____ Other____

☐ **Estimated Disposal Cost Saving**

Decrease in TSDF Fees ____

Decrease in State Fees and Taxes ____

Decrease in Transportation Costs ____

Decrease in Onsite Treatment and Handling ____

Decrease in Permitting, Reporting and Recordkeeping ____

Total Decrease in Disposal Costs ____

☒ **Estimated Decrease in Raw Materials Consumption**

Materials	Unit Cost $ per unit	Reduction in Quantity Units per time	Decrease in Cost $ per time
Developer			400/yr

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
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WORKSHEET 15e

COST INFORMATION

(continued)

EPA

☐ **Estimated Decrease (or Increase) in Ancillary Catalysts and Chemicals**

Catalyst/Chemical	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time

☐ **Estimated Decrease (or Increase) in Operating Costs and Maintenance Labor Costs (Include cost of supervision, benefits and burden).**

☐ **Estimated Decrease (or Increase) in Operating and Maintenance Supplies and Costs.**

☐ **Estimated Decrease (or Increase) in Insurance and Liability Costs (explain).**

☐ **Estimated Decrease (or Increase) in Other Operating Costs (explain).**

INCREMENTAL REVENUES

☐ **Estimated Incremental Revenues from an Increase (or Decrease) in Production or Marketable By-products (explain).**

Firm USAF	Waste Minimization Assessment	Prepared By G.C. Wahl
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WORKSHEET 15 f

COST INFORMATION

(continued)

EPA

INCREMENTAL OPERATING COST AND REVENUE SUMMARY (ANNUAL BASIS)

Decreases in Operating Cost or Increases in Revenue are Positive.
Increases in Operating Cost or Decrease in Revenue are Negative.

Operating Cost/Revenue Item	$ per year
Decrease in Disposal Cost	
Decrease in Raw Materials Cost	400
Decrease (or Increase) in Utilities Cost	
Decrease (or Increase) in Catalysts and Chemicals	
Decrease (or Increase) in O & M Labor Costs	
Decrease (or Increase) in O & M Supplies Costs	
Decrease (or Increase) in Insurance/Liabilities Costs	
Decrease (or Increase) in Other Operating Costs	
Incremental Revenues from Increased (Decreased) Production	
Incremental Revenues from Marketable By-products	
Net Operating Cost Savings	400

Firm USAF	**Waste Minimization Assessment**	Prepared By G.C. Wahl
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WORKSHEET 16

PROFITABILITY WORKSHEET # 1 PAYBACK PERIOD

EPA

Total Capital Investment ($) (from Worksheet 15c) 11,000

Annual Net Operating Cost Savings ($ per year) (from Worksheet 15f) 400

Payback Period (in years) = $\frac{\text{Total Capital Investment}}{\text{Annual Net Operating Cost Savings}}$ = 27.5

APPENDIX B

Scott AFB Waste Stream Identification and Waste Analysis Plan

ANNEX B TO WASTE ANALYSIS PLAN
WASTE STREAM IDENTIFICATION

SITE	ORG	SHOP	WASTE	EPA HAZARDOUS WASTE NUMBER
Bldg 352	375 CAMS	PME Laboratory	Waste Mercury	
			Lithium Batteries	
			Mercury Batteries	
Bldg 382	375 SUPS	Fuels Laboratory	Waste Fuel	
Bldg 433	375 CAMS	Hanger 1	Hydrualic Fluid	
		Hydraulic Shop	Skyryol	
Bldg 441	375 CAMS	Paint and	Paint Related	
		Cleaning Shop	Material(Safety-Kleen)	
Bldg 456	375 CAMS	Jet Engine Shop	Synthetic Oil	
	375 CAMS	AGE Shop	Hydraulic Fluid	
			Compressor Oil	
			PD 680	
			Mineral Oil	
Bldg 506	375 CAMS	Tire Shop	Solvents (SK)	
	375 CAMS	C-21 Aircraft	Waste Oil	
		Maintenance	Hydraulic Fluid	
			Solvents (SK)	
Bldg 515	375 CES	Grounds	Waste Oil	
		Maintenance	Waste Fuel	
Bldg 531	375 CES	Liquid Fuels	Waste Fuel	
Bldg 538	375 CES	Power Production		
Bldg 540	375 CES	Transformer Storage	PCB Oil	
Bldg 548	375 TRANS	Vehicle	Waste Oil	
		Maintenance	Antifreeze w/Hydraulic	
			Waste Fuel	
			Paint Thinner	
			Hydraulic Fluid	
			Batteries	
Bldg 700	1201 FPS	Printing Office	Z-Starter	
			Mega-Developer	
			Blanket Wash	F001
			Finisher	
Bldg 1192	375 ABG/SS	Golf Course	Waste Oil	
		Maintenance	Batteries	
			Solvents	
			Herbicides	
			Insecticides	
			Fungicides	
Bldg 1530	USAF Med Cntr	Hospital	Infectious Waste	
Bldg 1965	AAFES	Service Station	Waste Oil	
			Batteries	
			Antifreeze	
			Solvents (Zep)	
Bldg 1989	375 ABG/SS	Auto Hobby	Waste Oil	
Bldg 3184	375 TRANS	Vehicle Refueling	Waste Oil	
		Area	Waste JP-4	
			Antifreeze	

Headquarters 375 Aeromedical Airlift Wing (MAC)
Scott Air Force Base, Illinios 62225-5000
April 1990

ANNEX B TO WASTE ANALYSIS PLAN (OPR: 375 ABG/DE)
WASTE STREAM IDENTIFICATION

SITE	ORG	SHOP	WASTE	EPA HAZARDOUS WASTE NUMBER
Bldg 3190	1842 EEG	Circuit Board Fabrication	Sodium Persulphate	
			Ammonium Persulphate	
			Electroless Copper	
			Copper Electrolite	
			Hydrochloric Acid	
			Activator	
			Excellerator	
Bldg 3200	375 CES	Storage Shed	Waste Oil	
Bldg 3665	375 CAMS	MDI Laboratory	Flourescent Penetrant	
			X-Ray Paper	
			Waste Silver	
Bldg 3680	102 USAFASF	Aircraft Maintenance	Waste Oil	
			Batteries	
			Hydraulic Fluid	
			Paint Related Wastes	
			Paint Remover	
Bldg 3675	102 USAFASF	Vehicle Maintenance	Solvents (SK)	
			Waste Oil	
			Antifreeze	
			Hydraulic Fluid	
			Transmission Fluid	
			Contaminated Fuel	
Bldg 4001	375 SUPPLY	War Readiness	Waste Mineral Oil	
			Decontamination Kits	
			Gas Mask Filters	

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April 1990

APPENDIX 1 TO ANNEX B TO WASTE ANALYSIS PLAN (OPR: 375 CSG/DE)
WASTE ANALYSIS REQUIREMENTS

SITE	WASTE	GC/MS	GC/SS	EP TOX	COR	REA	IGN	O/G	PCB
Bldg 352	Waste Mercury			X					
	Lithium Batteries			X	X				
	Mercury Batteries			X	X				
Bldg 382	Waste Fuel		X				X		
Bldg 433	Hydrualic Fluid	X		X			X		
	Skyryol						X		
Bldg 441	Paint Related Material(Safety-Kleen)		X	X			X		
Bldg 456	Synthetic Oil	X		X			X		
	Hydraulic Fluid	X		X			X		
	Compressor Oil	X		X			X		
	PD 680		X	X	X		X		
	Mineral Oil	X		X			X		
Bldg 506	Solvents (SK)		X	X	X		X		
	Waste Oil	X		X			X		
	Hydraulic Fluid	X		X			X		
	Solvents (SK)		X	X	X		X		
Bldg 515	Waste Oil	X		X			X		
	Waste Fuel		X				X		
Bldg 531	Waste Fuel		X				X		
Bldg 538									
Bldg 540	PCB Oil			X			X		X
Bldg 548	Waste Oil	X		X			X		
	Antifreeze w/Hydraulic		X	X	X		X		
	Waste Fuel		X				X		
	Paint Thinner		X	X	X	X	X		
	Hydraulic Fluid	X		X			X		
	Batteries			X	X				
Bldg 700	Z-Starter	X		X	X	X	X		
	Mega-Developer		X	X	X		X		
	Blanket Wash		X	X		X	X		
	Finisher		X	X	X	X	X		
Bldg 1192	Waste Oil	X		X			X		
	Batteries			X	X				
	Solvents		X	X	X		X		
	Herbicides			X					
	Insecticides			X					
	Fungicides			X					
Bldg 1530	Infectious Waste	DISPOSAL BY INCINERATION							
Bldg 1965	Waste Oil	X		X			X		
	Batteries			X	X				
	Antifreeze	X		X	X				
	Solvents (Zep)		X	X	X		X		

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APPENDIX 1 TO ANNEX B TO WASTE ANALYSIS PLAN (OPR: 375CSG/DE)
WASTE ANALYSIS REQUIREMENTS

SITE	WASTE	GS/ MS	GC/ SS	EP TOX	COR	REA	IGN	O/G	PCB
Bldg 1989	Waste Oil	X		X			X		
Bldg 3184	Waste Oil	X		X			X		
	Waste JP-4		X				X		
	Antifreeze	X		X	X				
Bldg 3190	Sodium Persulphate								
	Ammonium Persulphate								
	Electroless Copper								
	Copper Electrolite								
	Hydrochloric Acid								
	Activator								
	Excellerator								
Bldg 3200	Waste Oil	X		X			X		
Bldg 3665	Flourescent Penetrant								
	X-Ray Paper	RESALE THROUGH DRMO							
	Waste Silver	SILVER RECOVERY DET 1 AUDIO VISUAL SQD							
Bldg 3680	Waste Oil	X		X			X		
	Batteries			X	X				
	Hydraulic Fluid	X		X			X		
	Paint Related Wastes		X	X			X		
	Paint Remover		X	X			X		
Bldg 3675	Solvents		X	X	X		X		
	Waste Oil	X		X			X		
	Antifreeze	X		X	X				
	Hydraulic Fluid	X		X			X		
	Transmission Fluid	X		X			X		
	Contaminated Fuel		X				X		
	Waste Mineral Oil	X		X			X		
Bldg 4001	Decontamination Kits								
	Gas Mask Filters								
	UNKNOWN	X		X	X	X	X		

ABBREVIATIONS:
GC/MS -GAS CHROMATOGRAPHY, MASS SPECTOMETRY
GC/SS - GAS CHROMATOGRAPHY, SOLVENT SCAN
EP TOX - EXTRACTION PROCESS (EP) TOXIC
COR - CORROSIVE
REA - REACTIVE
IGN - IGNITABLE
O/G - OIL/GAS
PCB - POLYCHLORINATED BIPHENYLS

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April 1990

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WINGFIELD
COLONEL
COMMANDER

Roger J. Girard Col, USAF
Base Civil Engineer

APPENDIX C

Kepro Plate-Thru System

KEPRO PLATE-THRU SYSTEM

Drill Connector holes
In copper clad
fiberglass circuit boards

→

Clean copper surfaces
remove all traces
of dirt, oil, etc.

CIRCUIT BOARD PREPARATION

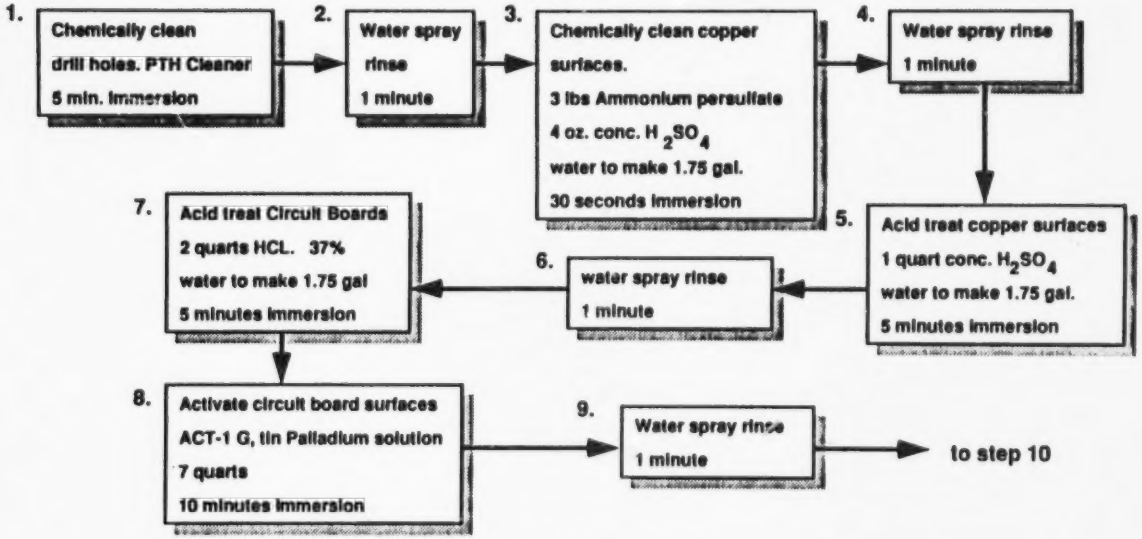

FIGURE 1. CONDUCTIVE COPPER DEPOSITION IN CIRCUIT BOARD HOLES
CIRCUIT BOARD PREPARATION THROUGH STEP 9.

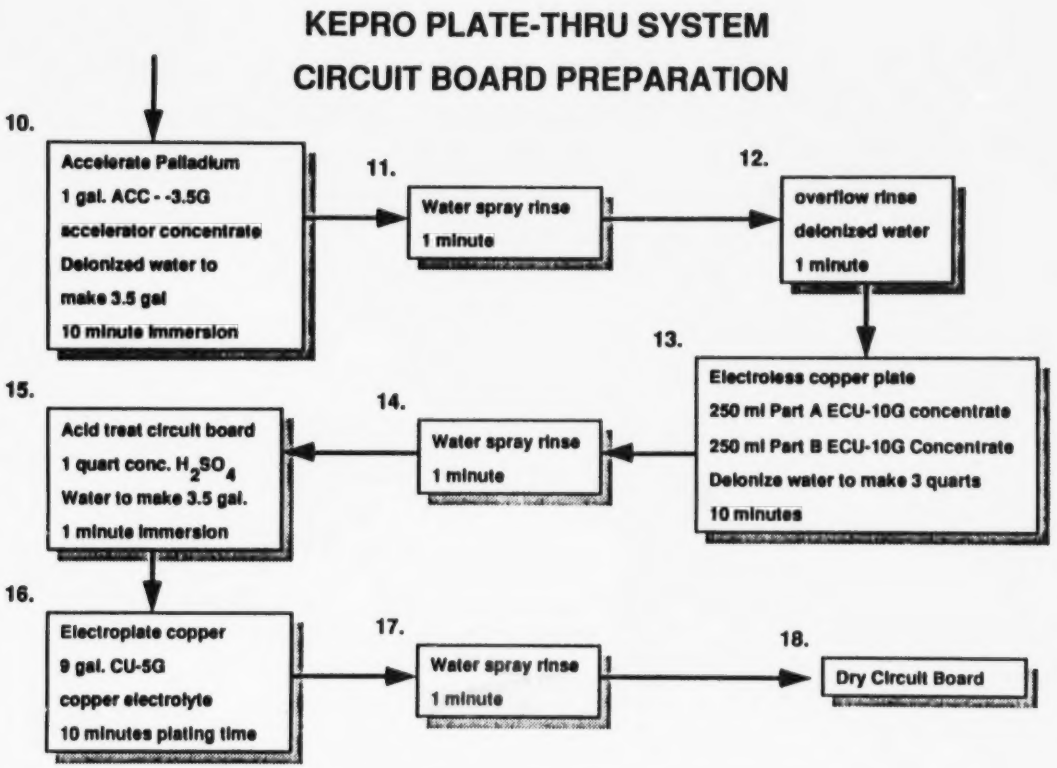

FIGURE 2. CONDUCTIVE COPPER DEPOSITION IN CIRCUIT BOARD HOLES
CIRCUIT BOARD PREPARATION STEP 10 THROUGH STEP 18.

KEPRO PLATE-THRU SYSTEM

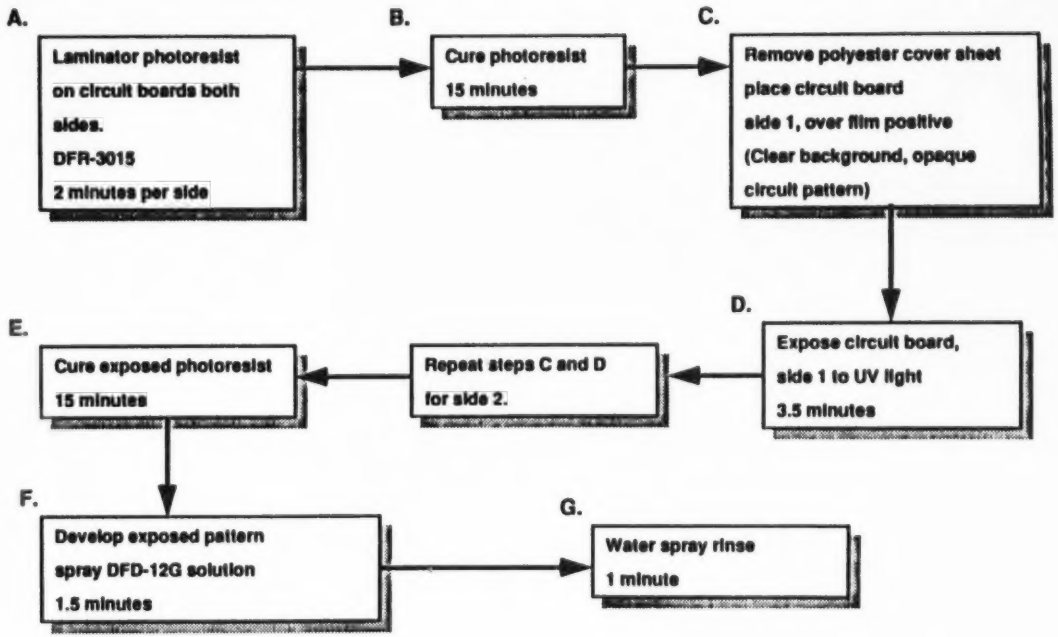

FIGURE 3. DELINEATE PLATING PATTERN

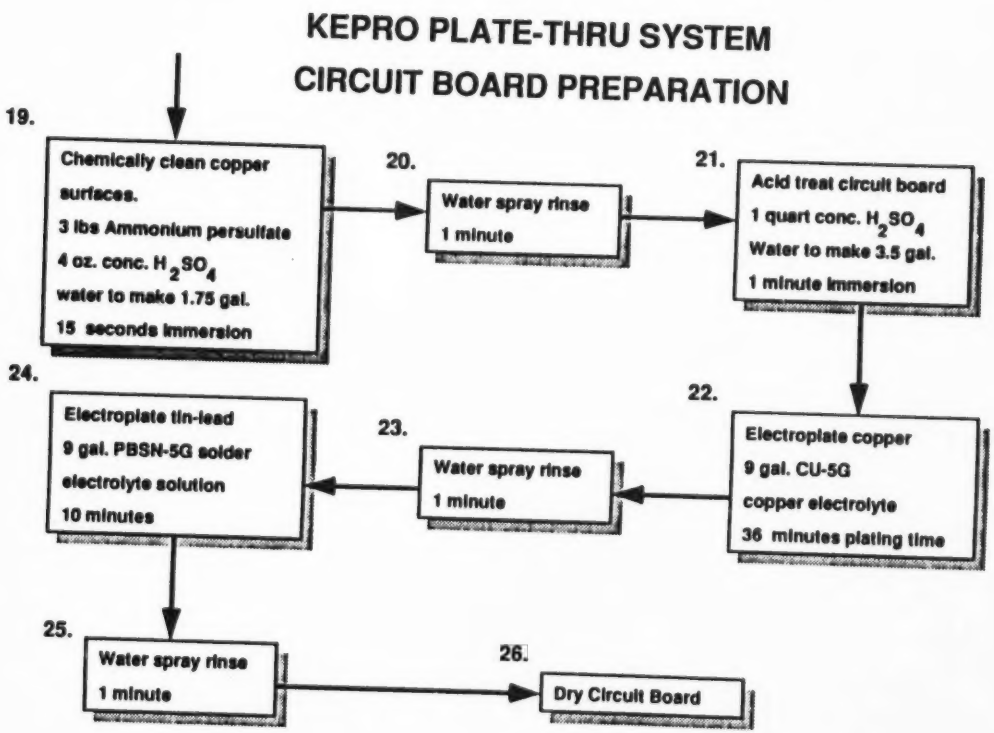

FIGURE 4. PATTERN PLATE COPPER, TIN/LEAD SOLDER
STEP 19 THROUGH STEP 26.

KEPRO PLATE-THRU SYSTEM

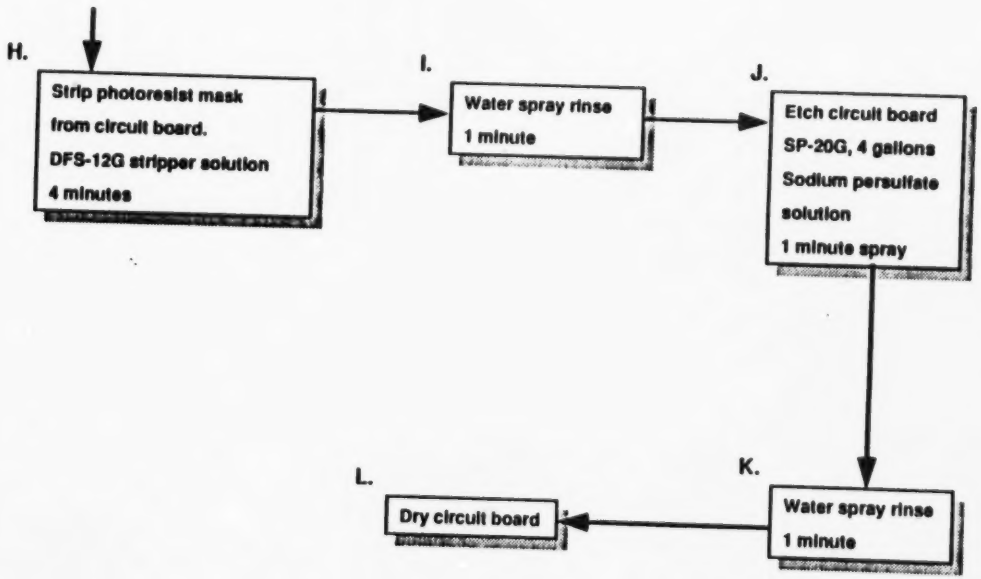

FIGURE 5. STRIP AND ETCH CIRCUIT BOARD STEPS H. THROUGH L.